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Losses Discretionary Reward

Tranche 3

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

1 Executive Summary

At Western Power Distribution we always seek to find better ways of working and our track record of innovation and change has helped us continually improve the way we deliver our services to customers.

The challenge of operating an efficient and economic network includes work to address the level of losses seen in the network. We are committed to improving our understanding of losses and translating this into cost effective measures that we can take to reduce losses.

Since our Tranche 2 submission we have been developing our approach further. In addition to our Losses and Innovation Strategies we have now published our Electric Vehicle Strategy. How we manage this new transportation demand on our network will affect losses and our strategy considers low loss equipment and new approaches will help mitigate this increase.

A key driver to the management of losses in the future will be our ability to manage effectively the additional demands created by all low carbon technologies as we transition towards Net Zero in 2050.

Our Losses Investigation project considered if it is possible to provide an accurate and consistent measured volume of losses.

Amongst other things it has demonstrated the low level of losses in relation to energy supplied. Working with other DNOs, the ENA Technical Losses Group have also completed research in this area to help us develop plans to measure this low level of total energy.

It draws upon international best practice and suggests an incentive with a long settlement duration may provide smoothing of measurement errors. Whilst measurement at all points remains one option we will look at the potential to use scenarios, models and templates to extrapolate losses from a smaller number of measurement points or across a wider settlement period.

Phil Swift

Phil Swift
CEO Western Power Distribution

2 Introduction

2.1 Structure

This Losses Discretionary Tranche 3 Award submission has been made by Western Power Distribution at a company level. It covers the four DNO licence areas of South West, South Wales, East Midlands and West Midlands.

2.2 Scope

This tranche 3 of the Losses Discretionary Award is a backwards looking report reviewing the actions taken by WPD during the Losses Discretionary Award period.

In the report WPD has focused on the processes and methods that have been employed to improve our understanding of losses; evidence of extensive and effective engagement, including sharing best practice with stakeholders; new processes to manage losses and proposals for RIIO-ED2; and finally, innovative approaches to losses management and actions taken to incorporate these approaches into business as usual activities.

All these actions are driving improvements to the way WPD manages losses, ensuring we go significantly beyond the actions required by the general licence obligations, thus reducing losses even further.

2.3 Format

WPD has followed the Ofgem recommended format and structured this report to address each of the assessment criteria listed in the LDR Tranche 3 guidance document.

Understanding losses

- Are DNO groups able to demonstrate how they are continuing to improve their understanding of the current level and sources of losses on their networks (including through the use of smart meter data)?
- Are DNO groups considering the network in a holistic manner and making efforts to understand how losses and their actions to manage losses on their network affect others e.g., those on the transmission and/or other distribution networks in an integrated way with their network capacity management and considering the needs of their stakeholders?
- What improvements/progress have DNO groups made since tranche one & two and how has their understanding of losses developed? Can they identify areas (from tranche one & two) that have allowed them to improve their understanding of losses?

Engagement and sharing best practice

- How are DNO groups planning to utilise stakeholder engagement to inform their losses management actions and allow them to understand their impact?
- How have DNO groups already engaged with stakeholders in this regard?
- How are DNO groups engaging with stakeholders (e.g. suppliers, distributed generators, the TSO, TOs etc.) to develop relevant partnerships which may help to manage losses (e.g. opportunities to use Demand Side Response)? This could include initiating a joint project where a reduction in losses is the primary driver or identifying opportunities within existing projects to help manage losses.
- Are DNO groups able to demonstrate that they have processes in place to share their own best practice with relevant stakeholders by identifying any outcomes of tranches one and two that they intend to do/carry on doing. This could include engaging with one another, the Transmission System Operator (TSO) and the Transmission Owner (TO) to facilitate a holistic and co-ordinated approach to losses management as they transition to DSO roles.
- DNO groups must verify that any stakeholder engagement actions are not already rewarded under the Stakeholder Engagement incentive that forms part of the Broad Measure of Customer Service to ensure the same activity is not rewarded multiple times.
- Following tranche two, what collaboration have DNO groups had with each other and other stakeholders? How have they ensured and how will they continue to ensure, collaboration on losses management?

Processes to manage losses

- Do DNO groups continue to look at best practice, both nationally and internationally, when considering processes and methods to manage losses on their networks? What have DNO groups learned from tranche one and two, which they have used or will intend to use going forward?
- How are companies preparing to effectively use smart meter data to develop specific actions to manage losses? What processes do the DNOs have in place now, following tranche one and two submissions?
- Have the DNO groups considered whether any of the actions they have taken from tranche one and tranche two and three will help feed into RIIO-ED2 on losses?
- What have the DNO groups considered for RIIO-ED2 when understanding and managing losses? We expect DNOs to have taken learning from the LDR in RIIO-ED1 to create proposals for how losses incentives should be managed in RIIO-ED2.

Innovative approaches to losses management and actions taken to incorporate these approaches into business as usual activities

- How are DNO groups planning to use innovative approaches to manage losses (including through the use of smart meter data) outside of projects funded through the RIIO-ED1 price control and the innovation stimulus mechanisms? What innovative approaches have DNO groups identified from tranches one and two?
- How will DNO groups incorporate these approaches into "business as usual" activities? Have the DNO groups incorporated any innovative approaches set out in tranches one and two to BAU?
- DNO groups must verify that the innovative activities are not funded under any other RIIO-ED1 financial initiatives. This is to ensure DNOs are not rewarded multiple times for the same activity. The aim of the LDR is to encourage DNO groups to undertake additional losses reduction actions over and above those set out in their business plans. For example, these might include identifying more cost effective and innovative ways of utilising the allowed revenue to enhance the reduction of losses.

2.4 Approach to Losses

The steps taken by WPD to reduce losses is informed by knowledge gained from research commissioned by WPD and more recently by all DNOs who participate in the ENA's Technical Losses group.

WPD's first significant piece of recent research was the SOHN Report "Understanding and Management of Electricity Distribution Network Losses", which was an IFI funded collaboration with UK Power Networks. This provided WPD with a strong action plan of recommendations. This was then followed by another significant piece of work as part of the NIA Losses Investigation project with the Isle of Man. This will be developed further by the upcoming WPD funded Superfast Electricity projects in South Wales.

These four projects have enabled WPD to build an important knowledge base around the source of losses. Using this knowledge will help WPD understand the impact of losses and what measures can be used in addressing them.

WPD is proud to work collaboratively with the other members of the ENA Losses group: we have completed two losses projects with UK Power Networks (UKPN) and Manx Electricity, and worked with Loughborough University and many others via the WPD Losses stakeholder events.

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Understanding of Losses

3.1 Reasons for Reducing Losses

DNOs are obliged, as part of the licence conditions, to reduce losses on their networks as far as reasonably practicable. In addition, stakeholders highlight this a key area of concern and their feedback is a key driver to ensure WPD devises a range of ambitious actions in this area that go beyond industry minimum requirements.

The importance of reducing electrical losses on distribution networks is growing as a result of the increase in intermittent distributed generation and higher production costs. It has only been in the RIIO-ED1 period that all the DNO's have publically documented Losses Strategies. The energy lost in distribution creates a financial cost which is paid for by our customers.

The energy lost (which includes theft) accounts for unnecessary carbon emissions, which impacts climate change, while also creating a financial cost which is paid for using societal costs.

Reducing losses effectively can also increase the network capacity, which is an essential consideration as energy consumption is likely to increase sharply in the near future as the take up of new technologies such as electric vehicles and heat pumps significantly increase as a result of the decarbonisation of transport and heating required by the Government(s) Carbon Plan 2011 and The Road to Zero Strategy 2018. By reducing losses wherever possible, it could reduce the need for costly network reinforcement projects.

WPD have addressed each of the Losses Discretionary Reward criteria in sections 3.2 to 3.4.

3.2 Projects to demonstrate improvement in understanding of the current level and sources of losses on networks.

3.2.1 SOHN Report

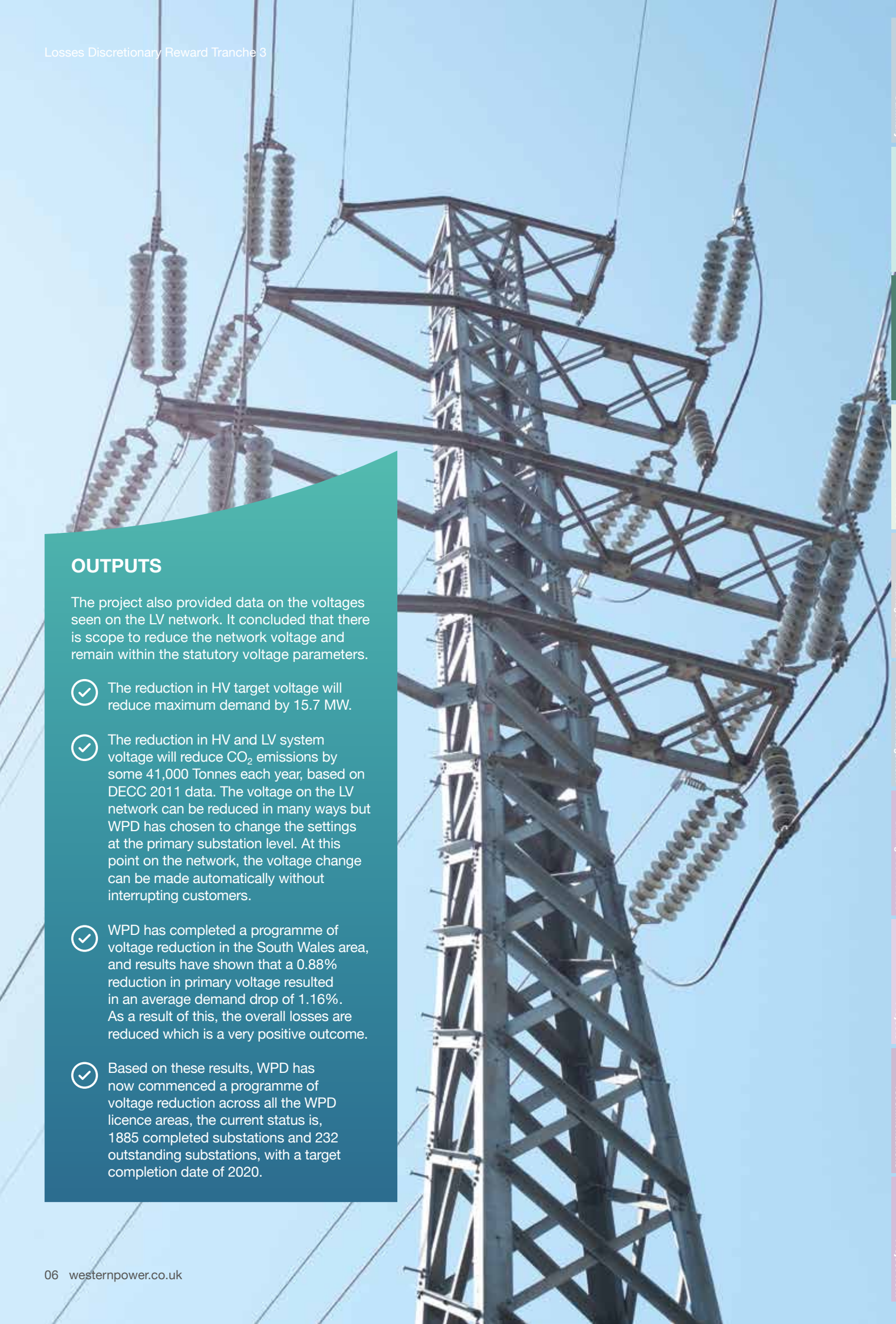
The SOHN losses report "Management of electricity distribution network losses" was commissioned by WPD and UKPN to provide an assessment of the ways in which losses could be reduced. The report was written in partnership by SOHN Associates and Imperial College London, to provide an academic viewpoint on the range of issues faced. The SOHN Losses Report suggests that losses use up approximately 7% of the power supplied to the distribution network.

The scope of the investigation was very broad, as the intention was to identify as many potential solutions to reducing losses as possible. Actions proposed included using a network modelling tool designed by Imperial College and intelligent forecasting for future demand. The report also considered possibilities such as heat recovery, active network management and asset replacement. In total, the project resulted in 26 recommendations for DNOs to consider, all of which have informed WPD's updated Losses Strategy and will be addressed throughout the remainder of RIIO-ED1. A full breakdown of the recommendations is included as an appendix.

3.2.2 LV Templates

The LV Templates project set up a highly monitored network in South Wales, with the aim to characterise substations into a number of 'templates' that could be used to describe the temporal load and voltage behaviour of substations nationwide.

The areas chosen for monitoring were selected due to high concentrations of low carbon technologies (LCTs) connected to the network, with the potential to be scaled up to represent the UK as a whole. A critical output from this project found that around 82% of UK substations fitted one of ten district templates identified in this project, meaning the opportunity to apply learnings from WPD's scheme to improve operations across the UK were very high.



OUTPUTS

The project also provided data on the voltages seen on the LV network. It concluded that there is scope to reduce the network voltage and remain within the statutory voltage parameters.

- The reduction in HV target voltage will reduce maximum demand by 15.7 MW.
- The reduction in HV and LV system voltage will reduce CO_2 emissions by some 41,000 Tonnes each year, based on DECC 2011 data. The voltage on the LV network can be reduced in many ways but WPD has chosen to change the settings at the primary substation level. At this point on the network, the voltage change can be made automatically without interrupting customers.
- WPD has completed a programme of voltage reduction in the South Wales area, and results have shown that a 0.88% reduction in primary voltage resulted in an average demand drop of 1.16%. As a result of this, the overall losses are reduced which is a very positive outcome.
- Based on these results, WPD has now commenced a programme of voltage reduction across all the WPD licence areas, the current status is, 1885 completed substations and 232 outstanding substations, with a target completion date of 2020.

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Understanding of Losses

3.2.3 Losses Investigation

This project aimed to further our understanding of technical losses on the distribution network and help us target them in a cost effective manner. The project was focused on technical losses on the HV and LV networks; losses in the following areas were not included: above the HV feeder circuit breaker; beyond the meter, and non-technical losses. Distribution Network Operators have an obligation to operate efficient and economic networks. As such the effective management of distribution losses is paramount. Previous estimates put the annual losses at between 5.8% and 6.6% of energy delivered (for all voltage levels) worth approximately £900 million across the UK. Approximately two thirds of this loss (£640 million) occurs after transformation down to 11kV. Some improvements, with clear cost benefits, are being rolled out, as outlined in WPD's Losses Strategy; however these have limits due to a lack of detailed understanding in the variation of losses across the network.

As such, reductions in losses on the existing network cannot be targeted on a feeder specific basis, meaning the network cannot be fully optimised. Without a detailed baseline characterisation of losses on individual feeders, it is also difficult to track changes in losses as future demand grows - such as with the uptake of electric vehicles, or to quantify the benefits of changes in the network planning policy. Data relating to the power consumed by all individual connections on an LV cable or network was not included in the scope of the LV Templates monitoring, as this was intended to measure the overall profile of a distribution substation.

Through a field-work programme for HV feeders, one minute resolution logging equipment is therefore being installed at the Primary Substation on the source breakers of the sample feeders, and at each load connection point along the feeder.

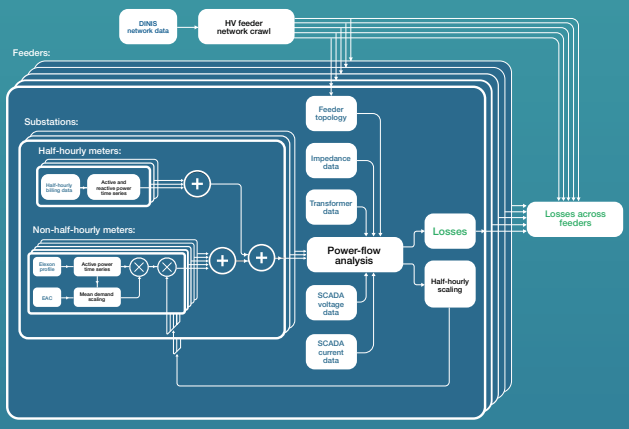
This provides comprehensive information about actual power flows for a complete HV feeder, allowing actual losses to be assessed for a specific feeder.

For LV feeders, one minute resolution logging equipment has been installed at Distribution Substations, monitoring the entry/exit of power onto LV feeders; and one minute data is being logged at all connection points along the sample LV feeders. As with HV feeders, this instrumentation provides comprehensive information about power flows for a complete LV feeder, and allows actual LV losses to be assessed for a specific feeder. The LV field work was carried out on the Isle of Man in collaboration with Manx Utility Authority. The Losses Investigation report has been completed, but as the initial focus was WPD's East Midlands region this project has now been extended to the whole of WPD's licence areas.

OUTPUTS

With development of the HV feeder loss estimation process now complete, feeder-specific annual mean loss estimates have been generated for 2130 feeders in the East Midlands region of WPD, the three remaining WPD areas are currently being developed. Details of findings and learning for the HV loss estimation work are available, with key items including:-

Method - for each HV feeder, the loss estimation method combines network topology data with demand data in order to run a power-flow analysis from which the individual feeder losses are calculated. These individual feeder results are then collated so that loss characteristics of the overall HV feeder set can be examined and identified. An outline of the method is shown in Fig 1:-



The results of the loss estimation method for the monitored HV feeders have been found to be in good agreement with the actual loss assessments of these feeders using the measured data.

Results - one of the fundamental outputs from the HV feeder loss estimation result set is a scatter plot of mean total loss power versus feeder mean power, see opposite. Many other forms of analysis are provided, and these are detailed in the recent final report.

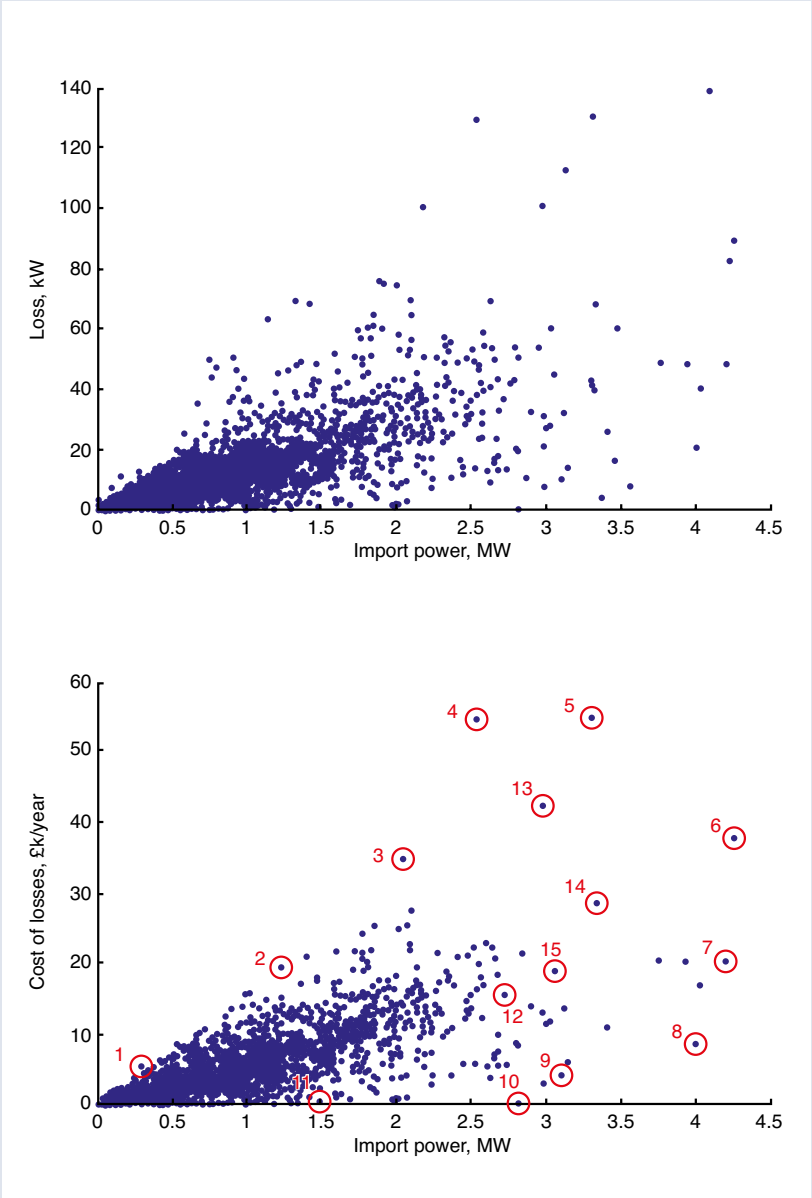
Validation - In addition to overall method validation, a number of outlying results have been reviewed. The review of each feeder included: feeder topology, together with broad characterising metrics and drivers of the level of loss.

The review also considered potential opportunities to reduce the losses, as a test of the capability of the analysis to support mitigation investigation work. The feeders included in the validation work are highlighted on the plot shown below, with the vertical axis now representing the annual cost of individual feeder losses.

In all 15 cases reviewed, the estimated level of loss could be linked to characteristics of the network (e.g. length, cross-sectional areas number of connected transformers), and the load (e.g. how the load is distributed across connected substations, and the location of dominate loads on the HV feeder).

Signposting - The HV feeder loss estimation process has demonstrated how HV feeders with high losses can be identified. These high loss feeders can then be reviewed to assess the cost-benefits of loss mitigation. The results also identify a set of higher loss individual feeder branches, and possible higher loss distribution transformers.

Learning - Detailed points of specific learning are described in the final report.



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Understanding of Losses

3.2.4 OpenLV

The OpenLV Project trialled an open, flexible platform that could ultimately be deployed to every LV substation in Great Britain. Through three key methods, the project demonstrated the platform's ability to provide benefits to the network, customers, commercial entities and research organisations.

Once deployed, the OpenLV platform can be used to provide data to individual customers or wider communities.

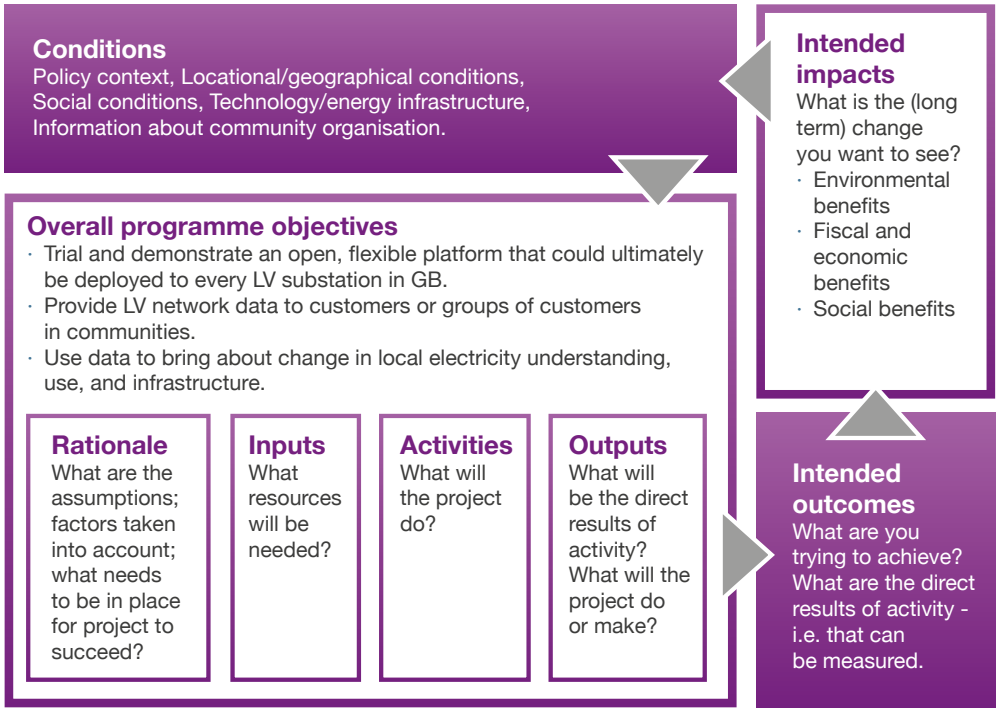
As customers better understand their electricity usage as a community, and their local network performs in a more efficient way balancing demand and generation, the overall volume of losses seen on the network will drop as peaks are reduced.

The Method 2 trials involve the active engagement of communities to provide organisations and individuals with direct access to LV network data through a secure third party hosted service. This is unique to the OpenLV project so there is learning to be gained from looking at how this will be achieved with the community engagement trials, and the ways in which community organisations propose to use LV network data in their communities.

OUTPUTS

The logic model provides a means of planning community-based project activity to achieve a set of outcomes for use of the OpenLV data, as well as a structure against which to evaluate the trials.

The flow-chart opposite shows the basic template which was used. Much of the content of the logic models was common to all the projects, particularly in terms of project activities and intended outcomes.



3.2.5 FALCON

Project FALCON was a Low Carbon Network Fund initiative started in 2012 that set about to test the following:-

"The general assertion being that the cost and limited flexibility of traditional approaches to 11kV network reinforcement threaten to constrain the uptake of low carbon technologies."

In order to really test this assertion FALCON had a number of dependent and standalone work streams.

With respect to Losses, FALCON concluded: -

- **Dynamic Asset Rating (DAR)** - DAR was investigated within the WPD FALCON project and as this technique may allow higher levels of current to pass through an asset under certain conditions. By definition, losses in a dynamically uprated asset would rise in comparison to losses that would relate to an asset of larger capacity had traditional reinforcement taken place. In the context of a losses strategy, the application of the technique would need an asset/network specific cost benefit analysis that considered the capacity benefit and cost of implementation, including any projected increase in losses during active periods.
- **Automatic Load transfer (ALT)** - ALT was investigated within the WPD FALCON project and indicates that the one-off static re-location of NOPs may have some potential to reduce losses. From the FALCON trials undertaken, relocating 11kV NOPs to the optimum position for losses can reduce the 11kV element of losses by 8% to 12% (the greater potential saving occurring on overhead networks). The potential benefits from NOP movements have also been looked at under WPD's Losses Investigation project.
- **LV connected Energy Storage on an 11kV feeder (ES)** - ES was investigated within the WPD FALCON project. The installed systems demonstrated effective peak-shaving at both individual substation and feeder level. This illustrated how energy storage shifts load in time, reducing load at a capacity constrained key point in time, only to increase the load at a less critical point in time. This reduction in peak current clearly reduces losses on the network, though the reduction in losses varies depending on the time of day that the demand is shifted to. However, the storage system has intrinsic technical losses (e.g. efficiency of the storage system, auxiliary loads associated with temperature management of the batteries etc.), that must be considered. Results from FALCON trials suggest the installed energy storage caused a net increase in losses, and that storage system losses would have to reduce significantly before this finding changed. Therefore the case for introducing any energy storage systems as an integral part of the Distribution network should include an assessment of the impact on losses.

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Understanding of Losses

3.2.6 Network Equilibrium

The focus of the Network Equilibrium project is to balance voltages and power flows across the distribution system, using three methods to integrate distributed generation within electricity networks more efficiently and improve voltage and power flows: Enhanced Voltage Assessment (EVA); System Voltage Optimisation (SVO) and a Flexible Power Link (FPL).

In some places, parts of the higher voltage networks are run in parallel with the lower voltage networks. This means there is more than one open point between the two levels of the network. The advantage of this configuration is that it allows loads to be better balanced. With the FlexDGrid and Equilibrium projects WPD has developed methods to monitor and automatically reconfigure networks. There are areas of the network where it is not possible to operate with parallel feeding arrangements (meshing) due to technical limitations. These can be due to loads, generation or fault levels.

OUTPUTS

- The EVA method enables the two technology solutions, SVO and FPL, to be suitably modelled and understood. The EVA also demonstrated the value of expanding the current voltage statutory limits for 11kV and 33kV networks to +/-6% and +/-8% respectively. This would facilitate an increase in utilisation of the existing system removing or deferring the need for additional asset investment. These models will also enable the network to be optimised in terms of full system losses, aligned with the learning from LV Network Templates and reducing the voltage as strategic points on the network.

- The SVO method assesses the operational state of the network in real-time, considering connectivity and connected load and generation, to determine the optimal voltage and then communicate these calculated values to the on-site voltage control relays to implement the voltage change. The SVO system will then calculate the optimised voltage level, lowest value for generation inclusion and highest value for load facilitation, enabling on-site changes to voltage to occur. The system went live in March 2018 and has demonstrated significant network value through actively being able to control the voltage on the system.

- The FPL device is an AC-DC DC-AC converter provided by ABB, which has been built, tested and was installed on the live Exebridge substation 33kV system in June 2018. This has enabled WPD to connect the Barnstaple and Taunton BSPs networks in parallel, providing the flexibility to move real and reactive power around the network to optimise the operation of the system and enable increased utilisation of the existing assets.

- The FPL aims to enable active power transfer between two network groups whilst independently controlling reactive power between each of the two grid groups to provide additional voltage support. The device works by connecting the two, previously distinct, networks together with two back-to-back AC-DC converters, removing any phase displacement or fault level constraining issues that currently exist. The device itself produces relatively high levels of loss so it will only be used for short periods when the losses benefits outweigh the costs. This has been trialled and the benefits of the FPL have been demonstrated to ensure that there are no network violations on the system whilst enabling more generation to connect to the system.

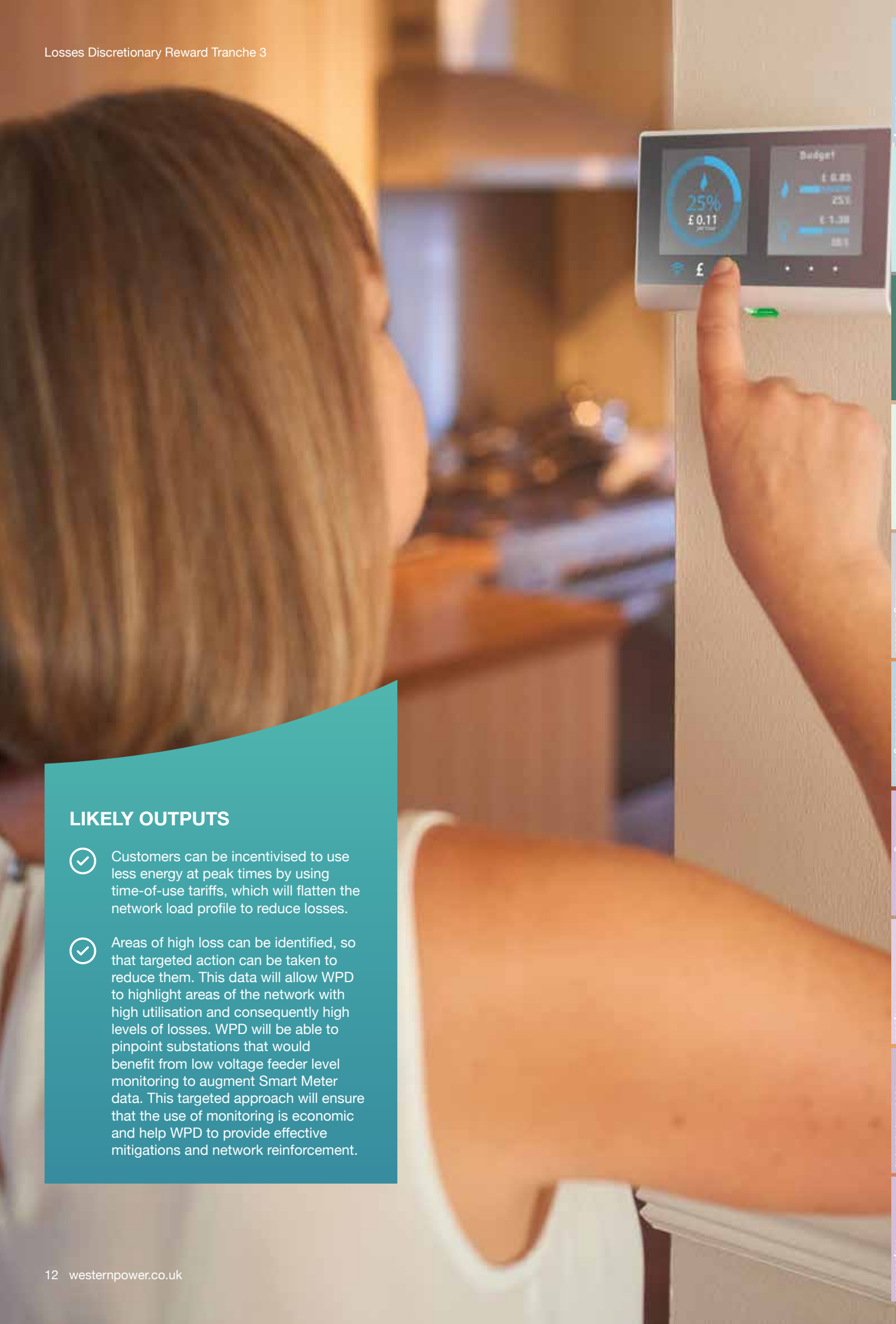
3.2.7 Smart Meter data

WPD will use consumption data in the future to look at feeder load and current to see if the load curves currently being used have changed. From Q1 2020 we will also use voltage data to identify any voltage issues on feeders.

The new Smart Meter programme deadline of 2024 should see 80% minimum penetration by the start of 2025. As quality data becomes more readily available, this will make planning and knowledge of the LV network more reliable.

SMETS 2 metering units have only been installed since late 2018. WPD has been building systems to receive and analyse the data, and were the first DNO to receive Ofgem approval for our data privacy plan in 2018. SMETS1 units have started being enrolled into the DCC so eventually DNO's will be able to access valuable data from them. WPD continues to engage with the DCC to find solutions to improve this.

Once data communications with DCC are improved, smart meter data can then be used by WPD to develop specific actions to manage losses.



LIKELY OUTPUTS

- Customers can be incentivised to use less energy at peak times by using time-of-use tariffs, which will flatten the network load profile to reduce losses.
- Areas of high loss can be identified, so that targeted action can be taken to reduce them. This data will allow WPD to highlight areas of the network with high utilisation and consequently high levels of losses. WPD will be able to pinpoint substations that would benefit from low voltage feeder level monitoring to augment Smart Meter data. This targeted approach will ensure that the use of monitoring is economic and help WPD to provide effective mitigations and network reinforcement.

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Understanding of Losses

3.3 Considering the network in a holistic manner and making efforts to understand how losses and actions to manage losses affect others

WPD consider the network in a holistic manner and make efforts to understand how losses and the actions to manage losses on the network affect others e.g., those on the transmission and/or other distribution networks in an integrated way with their network capacity management and considering the needs of their stakeholders.

A tool was developed as part of the Losses that uses the data obtained to characterise all the feeders within an Electricity Supply Area, as detailed in 3.3.1.

3.3.1 Losses Investigation Project

The project installed monitoring on 22 HV and LV feeders, with the aim to develop methods to assess technical losses on non-monitored HV and LV feeders using minimal additional monitoring. These monitored circuits provided corroborated, actual feeder loss information to further our understanding of technical losses, and acted as a control group for testing alternative methods of assessing losses for the widespread feeder-specific assessment.

OUTPUTS

We have successfully developed a number of methods to assess losses on HV and LV feeders without the need for additional monitoring information over and above that which is available through business-as-usual channels. These methods are based on power flow calculations for individual feeders, using feeder-specific topology and high time-resolution load models over a one year period.

- These methods have been calibrated against the monitored feeders, and agree well with losses calculated using the full monitoring data.
- In addition, the developed methods have been successfully applied to over 75% of the HV and LV feeders in the East Midlands license area, involving over 71,000 network and load feeder models. The project has therefore demonstrated the feasibility of widespread feeder-specific assessment of losses and has created detailed information characterising losses on HV and LV feeders in the East Midlands.

The Losses Investigation report is now nearing completion. The HV estimation process is fully developed and has been demonstrated internally using HV feeders in the East Midlands. Loughborough University is currently producing the HV estimation process for the South West, South Wales and West Midlands. The LV estimation process is now well developed, for the East Midlands with refinements currently underway on the demand model and rollout commencing for the South West, South Wales and West holistic view of losses across our four licence areas or both LV and 11kV networks.

3.3.2 Management of Losses on the Network

WPD's LV and 11kV system modelling tools include losses calculations for each scenario used. However, as one of the first measures WPD undertook was to increase the underground cable size and removed cable tapering, upgrades are uniform across the company.

OUTPUTS

- WPD's planners are able to comply with the majority of losses designs by using the uprated selection of cables and transformers made available in 2016.
- At EHV WPD currently uses two system modelling tools, PSS/E and IPSA. PSS/E can create losses calculations and has become the standard system within WPD since Q4 2019. Whilst all EHV designs are bespoke, WPD has completed work to provide template solutions for generation connections that incorporate the losses impacts.

The usefulness of this modelling will be enhanced even further once used in conjunction with smart meter data, as it will enable models of the network to be produced in real-time. Data at specific metering points can then be predicted and compared to the real data, to determine the success of the model. The software will need to be redesigned to incorporate this feature. Once developed, it will be possible to create more targeted losses strategies, leading to far more effective loss reduction activities.

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Understanding of Losses

3.3.3 Management of Losses on the Future WPD Network

Computer modelling is an essential tool to forecast what will happen on the WPD network in the future and as well as performance on the unmonitored parts of the network. Once WPD has mastered the communicating with DCC then this modelling can be extended to ways to utilise data derived from the smart meters to manage losses.

It will do so by creating a virtual, fully monitored network that can then examine and test new ideas. WPD will be able to map where losses occur on the network, allowing for a targeted approach to loss reduction. Perhaps most innovatively it will model the impact on losses of all possible future actions on the network in response to future energy scenarios, to enable the best solution to be selected. This DCC information can then be fed into the DFES generation process thus enhancing the bottom up approach with losses data.

Since 2016 WPD have been producing Distribution Future Energy Scenarios (DFES) at a license area level which predict the likely impact of LCTs along with other new technologies. The scenarios use a bottom up approach to provide future energy scenarios, at Electricity Supply Area (ESA) level, for the potential growth of distributed generation, electricity demand growth and electricity storage. These are then used to identify future constraints on the distribution network and develop strategic investment options to economically resolve those constraints, when triggered.

The analysis undertaken for each technology in the DFES involves the following four stages:-

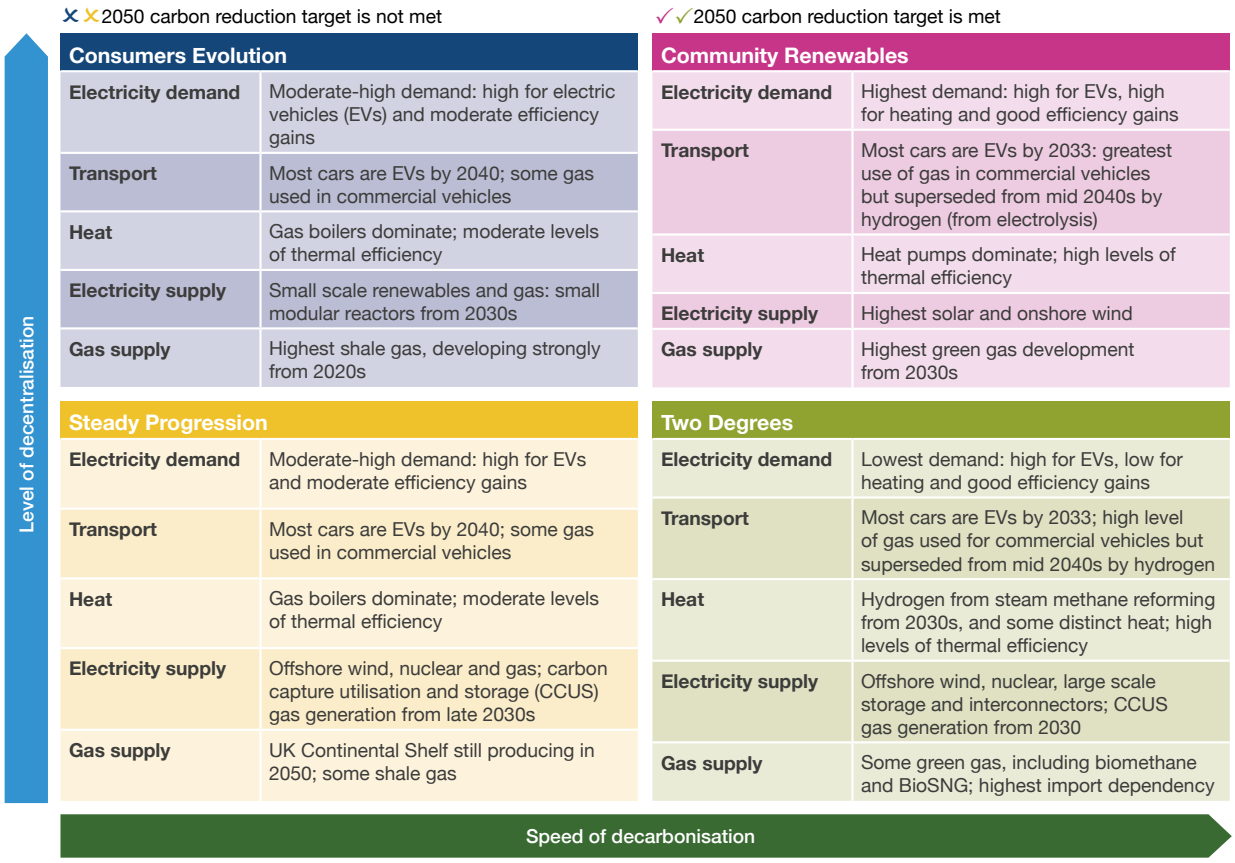
1 A baseline assessment
Technology baselines are calculated from WPD's network connection database. This information is then reconciled with other market intelligence and external databases.

2 A pipeline assessment
For technologies with significant lead times WPD's network connection agreement database is reconciled with the BEIS planning database and further informative market research is undertaken. This allows an assessment of the likelihood of which commercial projects in the pipeline may go ahead and in what timescale. Domestic scale and demand technologies do not have an individual pipeline, but local council economic plans are reviewed to derive volumes and locations.

3 Resource assessment
Locational data from a wide range of data sources and GIS analysis is used to understand the geographical distribution, local attributes, constraints and potential for technologies to develop within the licence area and each ESA. For heat pumps this is further broken down into two types of heat pump: electric and gas back up (hybrid systems). The scenarios also break down the heat pumps into three categories: retrofit on gas, retrofit off-gas and new build properties.

4 A scenario projection to 2032
The scenarios are based on National Grid's Future Energy Scenarios (FES) and interpreted for specific local resources, constraints and market conditions. Analysis of current market reports and the findings from a local consultation event is combined with interviews from developers, investors and other stakeholders.

WPD's scenarios are aligned with the following four National Grid Future Energy Scenarios:



3.3.4 The ENA Technical Losses Group

WPD meet regularly with the other DNO's and ESB, the Losses group commissioned consultants WSP to conduct a project on the Impact of Low Carbon Transition on Technical Losses on network types common to all DNOs.

'Impact of Low Carbon Transition – Technical Losses Report' revealed that losses are expected to be impacted by the predicted increase in electrical demands as Great Britain (GB) adopts Low Carbon Technologies (LCTs) for heat and transport such as heat pumps (HPs), electric vehicles (EVs) and photo voltaic solar generation (PVs).

Increases in demand are associated with increased losses; however, absolute losses could be reduced if larger conductors or additional circuits are added and network utilisation is reduced. Distributed generation connected in close proximity to demand reduces losses when the generation offsets power flowing through the wider network to supply the demands. However, distributed generation can increase losses when the generation is sufficiently in excess of the demand.

Building on this, in 2019 the ENA Technical Losses group commissioned WSP to produce a recommendation for a Regulatory Incentive Mechanism, the findings of which were shared with the wider industry at the LCNI conference in Glasgow.

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Understanding of Losses

3.4 Improvements and progress we have made since Tranche 1 and Tranche 2, and how this has developed WPD's understanding

3.4.1 Improving the Knowledge of Losses within WPD

We are building significantly on the learnings from WPD's LV Templates and Losses Investigation projects, including taking account of the impact on WPD of the Government(s) Road to Zero Strategy and the impacts of the required decarbonisation of heat and transport by 2050. For example:

WPD in partnership, with POBL and Sero Homes, have carried out all the design work and construction is underway with Parc Erin Housing as part of a flagship project where existing housing stock will be fitted with three phase LV service cables, solar panels, battery storage, heat pump, electric vehicle charging, smart washing machine and dishwasher. All the devices will be programme logic controlled. The housing estate will be fully monitored on the 11kV and LV side to determine the losses and load balancing on a three phase connected LCT housing estate compared to single phase connection.

Adopting a similar monitoring approach as to the Isle of Man, to the single phase Losses Investigation Project, WPD will produce an audit trail showing how losses are reduced by using three phase service cables on new build properties.

WPD's Superfast Electricity project is expected to correlate with, and test within a practical environment, the ENA Losses Group's WSP 'Impact of Low Carbon Transition – Technical Losses Report', which has shown that losses are expected to be impacted by the predicted increase in electrical demands as Great Britain (GB) adopts Low Carbon Technologies (LCTs).

4 Engagement and Sharing Best Practice

4.1 Topics Covered at Stakeholder Engagement

Jan 2014

General stakeholder engagement where losses were included as a topic
- The concept of losses
- Ways losses can be reduced
- Early versions of the WPD Losses strategy
- High level objectives and results

Nov 2014

Specific Losses stakeholder event
- SOHN losses report
- Losses strategy items including process of selection
- Cost benefit analysis
- Early transformer replacement for pre-1958 units
- Discontinuation of small sizes of transformers and cables for new works
- Design changes for networks to remove tapering
- Network phase balancing
- Revenue protection

Nov 2015

Specific Losses stakeholder event
- SOHN Losses Report
- Losses Strategy update
- Innovation projects and losses
- Low voltage cable length modelling
- Heat recovery from large transformers

Nov 2017

Specific Losses stakeholder event
- SOHN Losses Report
- Losses Strategy update
- Innovation Projects and losses
- Losses Investigation Project
- Measuring losses
- Collaborative Working
- Housing estates of the future
- Retro-fit service cables and loss reduction

Nov 2019

Specific Losses stakeholder event - in conjunction with SSEN
- SOHN Losses Report
- Losses Strategy update
- Losses Investigation Project
- Collaborative Working
- Housing estates of the future
- Retro-fit service cables and loss reduction
- Amorphous padmount transformer
- Primary transformer heat pump to heat substation
- SSE presentation on TASS / Lean project

4.2 Engaging with stakeholders

Much of the work WPD has carried out at an industry level is outlined in our Innovation Strategy. It includes a wide range of projects and initiatives that have achieved a reduction in losses as part of their targets to increase utilisation of the network.

Higher levels of utilisation will always increase losses, but a smoother demand profile can contribute to the overall reduction of network losses.

WPD use demand side response to reduce the peaks of load and associated losses on our network. As a result of our FALCON project, WPD found that the ability for customers to provide DSR to WPD is often restricted by the contracts they have in place with National Grid.

WPD has worked closely with National Grid to change the standard terms and conditions to allow customers to operate in both markets. Through our Flexible Power demand response provision we have taken this further.

In a world first, working with Centrica, the Local Energy Market (LEM) enables National Grid ESO and Western Power Distribution to simultaneously procure flexibility from the same platform. WPD has set up a DSR Forum, where DNOs, Ofgem and National Grid are represented, to discuss this in more detail, shared best practice and seek input to further refine the model to enable widespread adoption and replication across the UK.

4.3 Sharing best practice

Stakeholders are clear that they expect WPD to take a lead to engage with other network operators to develop and share best practice. WPD has a proven track record of doing so, as demonstrated by IFI project, the SOHN Report on Losses, which we completed collaboratively with UK Power Networks (UKPN).

This took place before the specific work on WPD's Losses Strategies and helped to shape our first strategy in this area. WPD have shared the project's findings with many other network operators and are pleased that elements of it are now commonplace in other DNO strategies. For example, Scottish and Southern Energy Networks (SSEN) not only shares our intervention on pre-1960 transformers, but has cited our IFI project as the research source.

Within the ENA Losses Group, Scottish Power Energy Networks and UKPN purchased amorphous transformers following presentations on the benefits of these. Within WPD the majority of our Primary and ground mount transformers already meet or exceed the current Eco design transformer specification. Using the information gained on amorphous transformers and as the Eco specification does not apply to single phase units WPD chose to purchase single phase low loss amorphous cored pole mounted transformers, thus going beyond the Eco design parameters. To this end Wilson transformers of Leeds were contracted to supply 90 25kVA single phase 250 – 0 – 250V 11kV transformers. The purchase of these transformers provided a positive CBA over the current standard equivalent transformer and are now in the process of being installed on the WPD 11kV network.

WPD's stakeholder engagement sessions inspired WPD to boost the scope and aspiration of the Losses Strategy. WPD made the following changes:

- Discontinuing small size cables for new works;
- Discontinuing small size transformers for new works;
- Using a "next size up" design policy;
- Targeting the early retirement of older transformer designs.

These topics are now included in many UK DNO Losses Strategies and demonstrate a good level of national best practice.

While WPD's research into the optimum length of low voltage feeders did not produce any evidence to change WPD proposals, the research WPD conducted with SOHN Associates has been presented as a paper in the CIRED conference held in Helsinki in June 2016.

With WPD's Losses Investigation project there have been regular updates on this project in WPD's Losses Stakeholder events, at the LCNI and WPD's Balancing Act events where all our innovation projects are disseminated. All the documents are available for download on the WPD Innovation website.

WPD is also keen to learn from others and use their research to develop WPD's future plans. WPD's Losses Strategy includes topics highlighted in other DNO strategies and this collaborative approach continues. One of the items for further research in the current strategy is the de-energisation of plant when not required. WPD is investigating SSEN's Low Energy Automated Networks LCNF project with a view to explore the viability in adopting the process. We were keen to welcome the SSEN team to our 2019 Losses Stakeholder Event.

WPD is pleased to see that other DNO losses strategies now include some of the elements of the WPD SOHN plan. All DNOs face similar issues so this kind of peer review and inclusion is a fantastic development to bring consistency across our operations and bring common benefits for all UK customers.

4 Engagement and Sharing Best Practice

4.4 Stakeholder Engagement Actions covered under other mechanisms

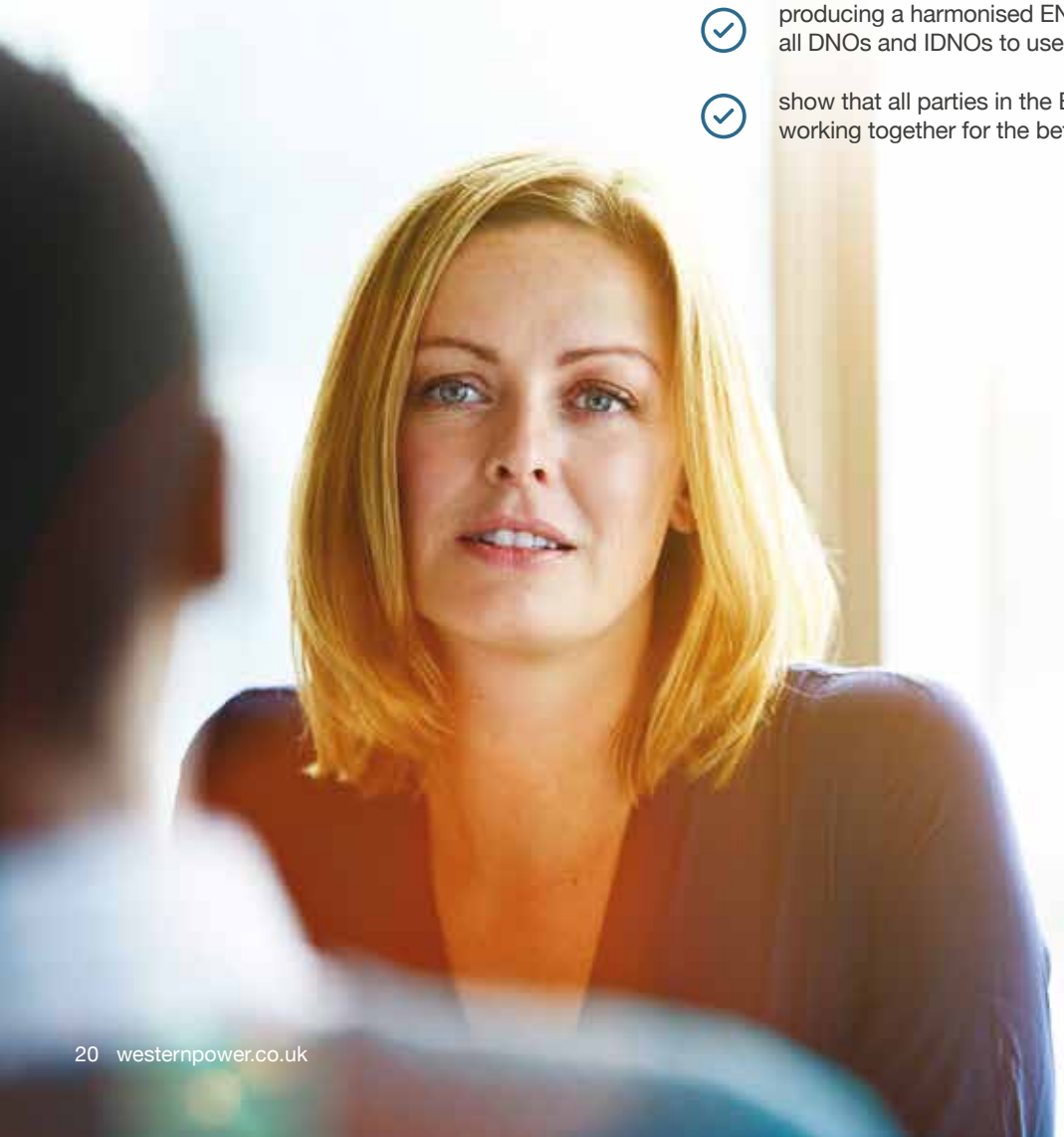
WPD can verify that any Losses Stakeholder Engagement actions are not already rewarded under the Ofgem Stakeholder Engagement and Consumer Vulnerability Incentive.

4.5 Post LDR Tranche 2 collaboration with other DNO groups

Post LDR Tranche 2 deliberations have seen the ENA Technical Losses group issue a contract to WSP to produce recommendations on a future Regulatory Incentive Mechanism, with findings shared at the LCNI conference in October 2019.

WPD has initiated an action via the ENA Losses group to produce a common DNO specification for both ground mount and pole mounted 11/0.4kV amorphous cored transformers thereby:

- producing a harmonised ENA document for all DNOs and IDNOs to use;
- show that all parties in the ENA Losses group are working together for the better good of UK plc.



5 Process to Manage Losses

5.1 Management of Losses

WPD is continuing to look at best practice and holistic systems when managing losses. Much of the UK knowledge of losses management is developed out of our joint project with UKPN. WPD has addressed each of the Losses Discretionary Reward criteria in sections 5.2 to 5.6.

5.2 Using best practice

WPD is continuing to look at best practice, both nationally and internationally, when considering processes and methods to manage losses on their networks. Using information provided by UKPN WPD have purchased amorphous cored Pole Mounted Transformer which exceed the Eco design on transformer losses.

5.2.1 National Losses Work

In 2014 WPD and UKPN collaborated and commissioned the SOHN Report on losses, this report has formed the backbone to the WPD Losses Strategy as it provided an impressive 26 recommendations (see appendix – SOHN Recommendations) for further work and action, delivery of which is ongoing throughout the RIIO-ED1 period, with adoption into business-as-usual operations as soon as possible. In addition these recommendations have driven new, specific objectives within many of WPD's innovation projects since 2014 in order to help the wider industry gain a better understanding of losses and actions we can collectively take to reduce them.

5.3 Non-Technical Losses

In many cases, theft in conveyance occurs when a non-standard connection is made directly to the WPD network, or where a service to a new property is installed and connected to the network without WPD's knowledge but using 'industry standard' equipment.

It is often difficult to identify these connections, especially where the property is rented and the landlord states that energy bills are included in the rental payments. In an effort to reduce theft of electricity from the network WPD is currently cross-checking records of both MPAN and UPRN databases. By assuming all properties with a UPRN have an electricity supply and filtering out all those that do, WPD is left with a list of those that don't have a supply and some of these might be unregistered connections.

For unmetered supplies (UMS) WPD have a set of processes which help maintain an accurate database of connections and loadings. WPD regularly visits local authorities to build working relationships with them. WPD also completes random audit checks on site to confirm the accuracy of the inventory. For small inventories, WPD sample 1% of the sites. When the inventory is large enough that 1% of the sites will be more than 200, WPD will sample 200 sites.

5.4 Process to Manage Non-Technical Losses

WPD's investigative work for suppliers uncovers around 8,000 cases per year of illegal abstraction.

Around 1,000 of these cases are related to cannabis production and, as a result, WPD work closely with local police. WPD identify around 2.8GWh per year of lost units which are passed through to suppliers for entry into the settlements process. Without this work these units would be recorded as losses on the WPD network.

5 Process to Manage Losses

5.5 Considerations for RIIO-ED2 when understanding and managing losses, including proposals for losses incentives in RIIO-ED2

5.5.1 Losses Incentive Mechanism for RIIO-ED2

The work completed as part of the ENA Technical Losses Working Group with the WSP Impact of Low Carbon Transition - Technical Losses report and WPD's own Losses Investigation project has helped WPD understand in practice more of the theory that was developed through the SOHN losses work. A crucial element of this improved understanding has been around the practicality of measuring losses accurately as investigated in our work with Manx Utilities.

The work on the Isle of Man has shown that, as expected, losses are a relatively small proportion of the total energy distributed across the WPD network. With levels of losses on the low voltage network being less than 5% in many cases the proportion being measured is so small it is almost down to the accuracy level of the smart meters which will be used to take the measurements. This makes the potential for errors in measurement being the unexpected factors that may drive results. WPD will refine our thoughts for a RIIO-ED2 mechanism as the project completes and will work out how the accuracy issues can be addressed. It may be that an incentive with a long settlement duration may provide smoothing of measurement errors to an acceptable level, but this will require statistical investigation before WPD can make any recommendations.

The Losses Investigation project also showed the difference between the I2R calculation method, which requires full modelled knowledge of the network and the Power Difference method which calculates the difference between the energy measured at the import and export points of the network. Power Difference appeared to offer a simple solution which would make use of smart meter data but the project has found that time synchronisation issues with the meters, even on the 1 minute measurements taken on the trial, add a level of error which tends to influence and mask the actual level of losses on the network.

The I2R method does not have these synchronisation issues but does require a design model to be built for each network and for the models to be kept up to date for all calculations. This work would be a significant issue for DNOs and, even if it were possible, the results obtained from it would be modelled rather than measured.

The WPD proposal for a Losses Mechanism for RIIO-ED2 would be one which takes account of the complexities of measuring such a small proportion of the total energy distributed. WPD is beginning to look at the potential to use scenarios, models and templates to extrapolate losses from a smaller number of measurement points or across a wider settlement period.

Raw levels of losses in kWh are of significance for any DNO, but a direct comparison with other DNO losses levels is more difficult as DNO losses depend not only on the network structure, but also on network energy flows. Losses rates make a comparison between loss and energy flow levels. Consequently, they provide reference values that may be comparable between networks, even if they are detailed by voltage level for relevant benchmarks.

Raw losses values and losses rates have to be calculated over long periods (at least 3 years) to ensure stability and robustness, as total losses for a given year may not be significant due to variability and uncertainty (due to data collection hazards or climatic conditions). In order to see the effect of reducing losses WPD needs to be able to determine the baseline level of current losses. The Losses Investigation project aims to establish such a baseline for several highly monitored LV and HV feeders picked to be representative of the main UK network topologies. This will allow WPD to better understand the locations of the losses on the network as well as the main causes.

5.5.2 Distribution System Operator (DSO)

WPD is moving to a Distribution System Operator (DSO) way of working which will see WPD managing energy flows across the network to increase utilisation and balance demand and generation. This has the potential to increase losses if power flows increase or demand and generation cannot be balanced. Alternatively it could reduce losses if the network was perfectly balanced. This balance must be achieved against an economic and efficiency measures so that the cost of losses can be considered. Work completed for the ENA Technical Losses Working Group by WSP – Impact of Low Carbon Transition – Technical Losses Report has shown that losses are expected to be impacted by the predicted increase in electrical demands as Great Britain (GB) adopts Low Carbon Technologies (LCTs) for heat and transport such as heat pumps (HPs), electric vehicles (EVs) and photo voltaic solar generation (PVs).

Increases in demand are associated with increased losses; however, absolute losses could be reduced if larger conductors or additional circuits are added and network utilisation is reduced. Distributed generation connected in close proximity to demand reduces losses when the generation offsets power flowing through the wider network to supply the demands, however, distributed generation can increase losses when the generation is sufficiently in excess of the demand.

Smart innovative technologies such as energy storage and active network management, have the capability to defer or mitigate traditional reinforcement, often resulting in greater average utilisation of assets. This increase in utilisation may however increase losses as a result, but the cost of increased losses with smart solutions is likely to be outweighed by the cost saving of alternative traditional reinforcement investment deferral. Overall, installation of smart solutions can be advantageous to customers' despite increased losses.

6 Innovative approaches to losses management and actions to incorporate in BAU

6.1 Innovative approaches to manage losses

WPD uses various methods to fund innovation projects, many of which have provided valuable insight on losses. This information is then taken and merged into current thus providing new planning and innovative approaches to manage losses.

This process also includes the use of smart meter data. WPD also directly fund projects which are outside the Innovation Funding Initiative (IFI), Low Carbon Networks Fund (LCNF) and Network Innovation NIA/ NIC funding of projects.

WPD has addressed each of the Losses Discretionary Reward criteria in sections 6.2 to 6.4.

6.2 Innovative approaches to manage losses outside of projects funded through RIIO-ED1

One of the main pieces of research carried out in 2014, and pre-dating RIIO-ED1, was the Management of Electricity Distribution Network Losses project. WPD completed this in partnership with UKPN.

As WPD was successful in being "fast-tracked" in the ED1 process, the final Losses Strategy which was used to drive our RIIO-ED1 plans was completed after the fast track decision. As a result, our work to reduce losses, including all cable size upgrades and transformer size changes, was funded by WPD directly.

6.2.1 Losses Projects Funded by WPD

In this sub section the projects listed are projects which have been wholly funded by WPD with a primary view of reducing Losses on the WPD network and how the work can then be transferred to BAU.

WPD has used any knowledge gained from previous funded work, so as to not re-invent the wheel and provide a good audit trail showing how the knowledge has grown and why solutions are being adopted. WPD funded projects are: -

SOHN - Circuit lengths and losses in low-voltage network design.

This project looked at the potential to reduce losses on LV networks by judicial reduction in length of LV feeders has been examined. This Report describes the Study which has been undertaken as a five-stage project. The key objective of the Study was to understand LV losses to the extent that a loss-inclusive approach may be taken to LV network design policy in terms of installation of the distribution transformers and the length of LV feeders. This was intended as a practical exercise, with an analysis of real networks and a realistic set of assumptions.

Losses benefit

From this work it is concluded that a policy of reducing losses by shortening feeders is not a compelling proposition. There is however evidence that with a threefold multiplier on network loadings a more optimal positioning of transformers would be more energy efficient and economically justifiable. There is also some indication that a second transformer would be justified on some single-transformer sites, but again only at a higher level of network loading. It is our view that the latest policies for applying economic ratings of cables and feeders and lower-loss transformers based on the Ofgem Guidelines, has effectively created an efficient LV network design.

HOUSING FOR THE FUTURE "Superfast Electricity" – New build.

With an eye on the Government(s) Road to Zero Strategy and the need to cut CO_2 emissions to 1990 levels by 2050 both transport and heating will be adding to the demand being drawn by housing with this in mind WPD is undertaking this project there is circa 250 new build houses which will be fitted with the complete suite of LCTs including PV and ES, with some EV charging WPD will be using three phase service cable supplies to feed these properties, with a view to reduce the losses to as lower a level as possible thus freeing up additional capacity.

Losses benefit

By combining the LV Templates work, 'The Losses Investigation' project and the 'Housing for the Future' project, WPD anticipates this work will show how the losses associated with the LV network can be balanced to reduce losses even though the load being drawn by the house has increased due to the addition of heat pumps and EV charging.

HOUSING FOR THE FUTURE "Superfast Electricity" – Retro-fit.

Again with this project WPD is looking to the future with the Government(s) Road to Zero Strategy and the need to reduce CO_2 emissions to 1990 levels by 2050, both transport and heating will be adding to the demand being drawn by housing with this in mind WPD is undertaking this project. As the majority of housing stock in the UK is circa 1950s, 1960s and 1970s where the service cable is a 0.0225in² PILC cable which is looped to the next door house this project is looking to reduce the losses when these homes get converted to meet the Government(s) net zero targets. With this project there are some 700 existing circa 1950s built houses which will be fitted with some LCTs including PV, ES, HP and some EV charging WPD will be using three phase service cable supplies to feed these properties.

Losses benefit

By combining the LV Templates work, The Losses Investigation project and the Housing for the Future project WPD expect that this work will show how the losses associated with the LV network can be balanced to reduce losses and the addition of heat pump and EV charging loads by using three phase services cables the losses are reduced even with the load on the house increasing.

6 Innovative approaches to losses management and actions to incorporate in BAU

6.3 Incorporating approaches into Business as Usual

Whenever WPD introduce innovation initiatives into BAU the process for doing so is as follows:

1. The pilot project is undertaken
2. Once complete, the results are then assessed and indicative pricing is obtained for a typical term contract period
3. A CBA is undertaken and the results compared to current methodologies
4. If the CBA is positive, specifications are written, policy documents written
5. Necessary training is considered and is recorded in the Implication Plan which forms part of the Policy document.

Implementation Plans are included with all our policy documents and detail what changes are planned, what actions are required within the business and the timescales of those actions. Whenever WPD make a change which relates to Losses the relevant policies are updated and specific implementation plans written. WPD use the process of policy production to assimilate innovative approaches into business as usual to provide a consistent approach across the company.

At its simplest, this is achieved by a local Team Manager explaining the changes to the team while more complex changes are shared using presentations and/or training sessions. WPD ensure that the adoption process can monitor the progress of innovations into BAU.

Example
Equipment Specification, Policy Documents, Roll out.

One of the losses innovations that has already been transferred into BAU is the removal of small size cables and transformers from our standard equipment pick lists.

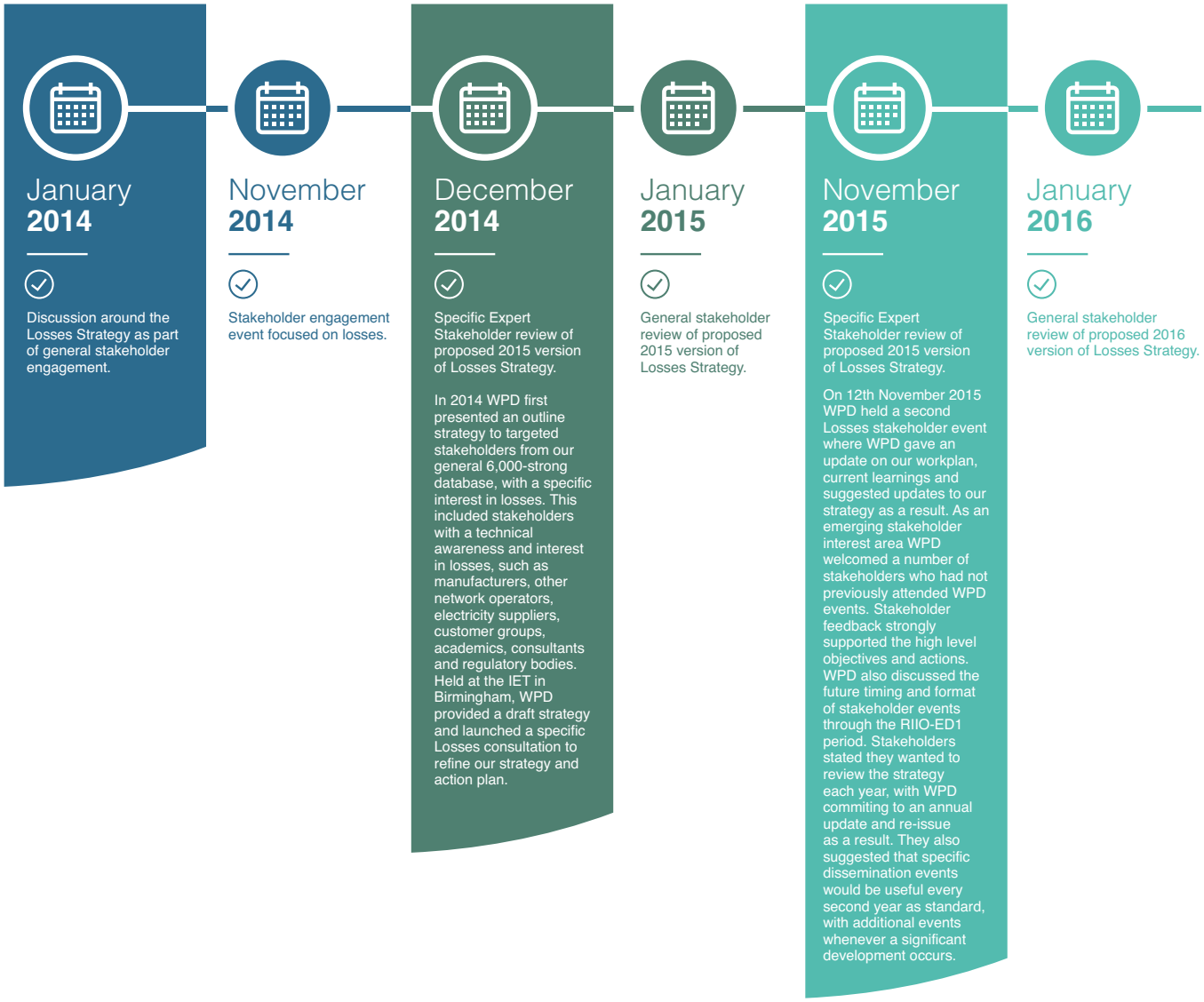
WPD achieved this by updating the specification documents for these items and by updating the G81 information WPD provide to Independent Connection Providers so that their network designs meet the new specifications.

6.4 Innovation funding

WPD can confirm that innovative losses activities have been carried out outside of other RIIO-ED1 financial initiatives, this ranges from the asset upgrade provisions developed after the agreement of the ED1 plan through to the projects which are being supported by WPD rather than being funded through any innovation funding mechanisms.

7 Appendix - Engagement and Sharing Best Practice

7.1 Utilising Stakeholder Engagement to inform losses management actions



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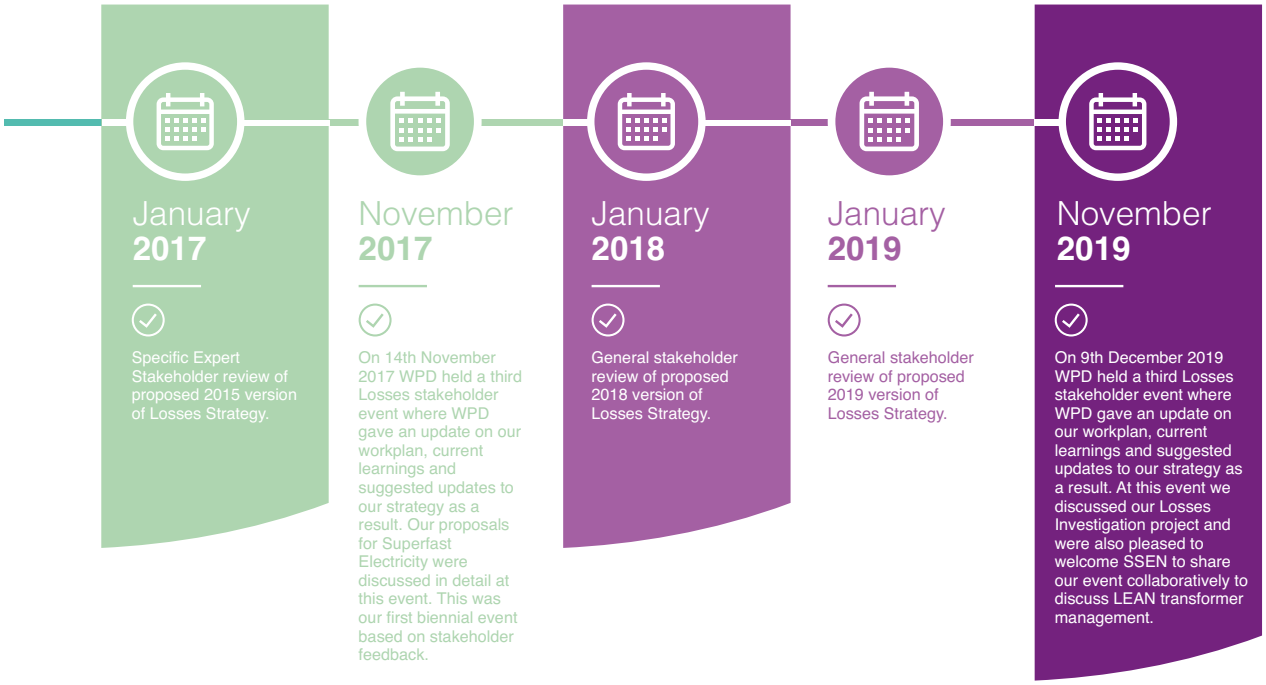
Appendix - Engagement and Sharing Best Practice

7.1 Utilising Stakeholder Engagement to inform losses management actions



8 Appendix – Hyperlinks to WPD Projects

In this section WPD is providing hyperlinks to every project that is mentioned in this report therefore giving the reader the ability to access the full and final report on each and every project.

Please use the interactive links below to read more details of our projects.

Network templates
For access to all data related to Network Templates: -
https://www.westernpower.co.uk/innovation/projects/network-templates

For access to just the final report for Network Templates: -
https://www.westernpower.co.uk/downloads/4898

Falcon
For access to all data related to Falcon: -
https://www.westernpower.co.uk/innovation/projects/falcon

For access to just the final report for Falcon: -
https://www.westernpower.co.uk/downloads/2542

FlexDGrid
For access to all data related to FlexDGrid: -
https://www.westernpower.co.uk/innovation/projects/flexdgrid

For access to just the final report for FlexDGrid: -
https://www.westernpower.co.uk/downloads/2180

Equilibrium
For access to all data related to Equilibrium: -
https://www.westernpower.co.uk/innovation/projects/network-equilibrium

For access to just the final report for Equilibrium: -
https://www.westernpower.co.uk/downloads/51982

Losses investigation
For access to all data related to Losses Investigation: -
https://www.westernpower.co.uk/innovation/projects/losses-investigation

For access to just the final report for Losses Investigation: -
https://www.westernpower.co.uk/downloads/51418

Open LV
For access to all data related to Open LV: -
https://www.westernpower.co.uk/innovation/projects/open-lv

For access to just the final report for Open LV: -
This project does not yet have a close down report

SOHN Report
For access to all data related to SOHN Report: -
https://www.westernpower.co.uk/downloads/4847

9 Appendix – SOHN recommendations

In this section we list all of the original SOHN report recommendations, with actions taken against each of them.

Recommendation 1

The network modelling and analysis tools used in the study are based on calibrated representative network models data. Given the increasing importance of losses, it would be appropriate that DNOs establish the capability of modelling and evaluating loss performance of their present and future networks, under different future development scenarios.

Action – This has now been adopted and become BAU for LV and 11kV. At LV with the WinDebut platform includes losses calculations for each scenario used.

Benefit for customers – WPD's LV and 11kV system modelling tools includes losses calculations for each scenario used. However, as one of the first measures WPD undertook in this area was to increase the underground cable size and remove cable tapering, this means upgrades are uniform across the company. WPD's Network Planners are therefore able to comply with the majority of losses designs by using the uprated selection of cables and transformers made available in 2016. At EHV WPD currently uses two system modelling tools, PSS/E and IPSA. PSS/E can create a losses calculation, it is envisaged that PSS/E will become the standard system within WPD by Q4 of 2019. Whilst all EHV designs are bespoke, WPD has completed work to provide template solutions for generation connections, these templates incorporated the losses impacts.

Recommendation 2

DNOs to consider carrying out more systematic data gathering associated with power factor to assess the materiality of the issue and to enhance the understanding of the costs and benefits of power factor correction at consumers' premises. The business case for power factor correction may then be developed.

Action – Since 2010 WPD has been including an excessive reactive power charge for HV and LV half hourly metered, via the Use of System Charge, with a power factor of 0.95 lagging.

Benefit for customers – This is to ensure that the reactive power is kept to the minimum. When sizing a circuit the total load has to be catered for, this means both the active load and reactive load, cumulatively, even though the customer would only effectively use the active load. By keeping the power factor at or about 1 means the customer is paying and using all the power. If for example they had a very bad power factor they could end up paying for one unit of power but in real terms only do half a unit effective work so they pay for the power that was wasted because of a poor power factor.

Recommendation 3

Further work is required to assess the extent of the imbalance problem and to test various solutions, which will not only reduce losses but deliver many other benefits of a well-balanced network. It may be appropriate to develop policies and working practices for avoiding excessive imbalance in future.

Action – WPD has completed the LV Templates project where imbalance was addressed. In addition WPD has just completed the Losses Investigation project in IOM where feeder and services (typically single phase) on the LV and 11kV systems are fully monitored, with data now being assessed by Loughborough University and subsequently published to share the learnings with others.

Benefit for customers – Using substations that are part of LV Templates project, WPD has identified that the phase imbalance in the LV network can lead to neutral currents at around 35% of the phase current. More recent work from the Losses Investigation Project suggests that ratios of neutral current to phase current are higher still. Majority of feeders have neutral current/mean phase current ratio above 0.35. Neutral current ratios tend to be higher for feeders with lower mean current. Going forward WPD is involved in a new build of circa 230 houses where the services will be three phase and all service and feeders on the LV and 11kV will be monitored in a similar manner to the IOM Losses Investigation project so a direct comparison can be made between the respective losses from single phase versus a three phase estate. The new build houses will also include EV chargers and Heat Pumps so that the out of balance can checked with the enhancement that is expected.

Recommendation 4

The inaccuracy of loss calculation using half-hourly data at the edges of the LV network should be recognised when conducting network studies.

Action – WPD's LV system modelling tool includes losses calculations for each scenario used, but as one of the first measures WPD undertook was to increase the underground cable size and removed cable tapering this means upgrades are uniform across the company.

Recommendation 5

As the benefits of peak demand reduction may be material, an assessment of the opportunities enabled by alternative SmartGrid techniques to achieve this should be carried out.

Action – WPD use demand side response to reduce the peaks of load and associated losses on our network. As a result of our FALCON project, WPD found that customers are often not able to help with DSR due to contracts in place with National Grid. WPD is working with National Grid to change their standard terms and conditions to allow customers to operate in both markets.

Benefit for customers – Centrica's new Local Energy Market (LEM) enables National Grid ESO and Western Power Distribution (WPD) to simultaneously procure flexibility from the same platform. WPD have set up the DSR Forum, where DNOs, Ofgem and National Grid are represented, to discuss this in more detail.

Recommendation 6

As the benefits of active voltage control in LV distribution network may be significant, comprehensive assessment of the opportunities to further reduce network losses should be carried out.

Action – WPD is reviewing the roll out of ENWs project Smart Street project which is using 11/0.4kV transformers complete with OLTC to address the issue of clusters of Low Carbon Technology where there are voltage fluctuations happening on an almost daily basis.

Benefit for customers - In addition the WPD Innovation team are undertaking a project with Efacec which will be looking to address the issues around dealing with wide variations of voltage on the LV network.

Recommendation 7

When considering active network management solutions and technologies to facilitate low-carbon connections, the impact on losses should be given full consideration Future Consideration.

Action – WPD, via the ENA Technical Losses group, commissioned WSP to undertake the Impact of Low Carbon Transition – Technical Losses Report.

Benefit for customers – In summary the report states losses are expected to be impacted by the predicted increase in electrical demands as Great Britain (GB) adopts Low Carbon Technologies (LCTs) for heat and transport such as heat pumps (HPs), electric vehicles (EVs) and photo voltaic solar generation (PVs). Increases in demand are associated with increased losses, however, absolute losses could be reduced if larger conductors or additional circuits are added and network utilisation is reduced. Distributed generation connected in close proximity to demand reduces losses when the generation offsets power flowing through the wider network to supply the demands, however, distributed generation can increase losses when the generation is sufficiently in excess of the demand.

Recommendation 8

There is a clear case for fundamentally reviewing cable and overhead line ratings to ensure that future loss costing has been included in the economic rating calculation. This could be based on Ofgem's loss investment guidelines or on loss-inclusive network design standards.

9 Appendix – SOHN recommendations

Recommendation 9

In future, losses may drive early asset replacement when economically efficient. If early replacement programmes are economically justified and capable of being funded, appropriate resources would need to be made available to facilitate delivery of such programmes.

Action – the following actions have now been rolled out as business-as-usual:

- Discontinued small size cables for large conductor size cables on new works
- Discontinued small size transformers for new works
- Adoption of a 'next size up' design policy
- Targeted early retirement of older than 1958 ground mounted transformer designs.

Benefit for customers – Asset replacement is the ongoing and most direct way in which WPD can reduce technical losses. From a losses point of view old transformers and underground cables encompass the majority of assets which provide the best value to a DNO and customer to reduce the losses seen on a network. With this in mind it then becomes part of business as usual that WPD will be changing pre 1958 ground mounted transformers for newer models which will reduce overall losses as new transformers have lower losses than old ones. In addition the variable losses in cables can be reduced by using cables with larger cross sectional areas, which also increases their capacity. Where overhead line conductors are replaced WPD aims, where possible, to replace smaller diameter conductors with larger diameter conductors as BAU.

Recommendation 10

The transformer loss calculations indicate that the benefits of investing in low-loss transformers may be significant and this should be considered further to establish or otherwise, the low-loss transformer business case in line with UK energy and carbon policy.

Action – WPD has always purchased low loss transformers since pre-privatisation and all primary and ground mount transformers meet or exceeded the Euro Eco design. In 2018 WPD purchased circa 100 amorphous pole mounted single phase transformers to install and monitor as single phase does not form part Euro transformer Eco design these are now being rolled out onto the network. In addition WPD is pushing the ENA Losses group to produce an industry standard for amorphous cored transformers.

Benefit for customers – All customers pay for the losses therefore by reducing the no load losses of the transformers reduces the wasted energy that would be necessary to drive those losses, it also then by default frees up extra generation.

Recommendation 11

Network designers may consider the option of installing additional distribution transformers to minimise LV network reinforcement cost and reduce losses.

Action – After the SOHN Report was produced WPD employed SOHN to undertake a redesign trial of recommendation 11 using the WPD new standard of large cross sectional area (csa) cables the trial showed no benefit in additional transformers. With the Government(s) Carbon Plan 2011, the Government(s) Road to Zero Strategy 2018 which layout the de-carbonisation of heating and transport and the introduction of 7kW EV chargers to all new buildings as part of the Building Performance Regulation change in April 2020.

Benefit for customers – WPD is now designing networks to cater for the increased loads and for decreasing the losses as BAU.

Recommendation 12

In the light of future developments, particularly in relation to the integration of low carbon demand and generation technologies, it may be appropriate to reconsider long-term distribution network design. This may take a strategic view of future voltage levels and include consideration of losses in the decision-making.

Action – WPD is involved in a new build of circa 230 houses in Parc Erin Tonyrefail where the services will be three phase.

Benefit for customers – All service and feeders on the LV and 11kV will be monitored in a similar manner to the IOM Losses Investigation project so a direct comparison can be made the losses on a single phase and three phase estate can be compared and analysed for out of balance on the LV main and unit transformer. The new build houses will also include PV, ES, EV chargers and Heat Pumps so that the out of balance can checked with the enchantment that is expected.

Recommendation 13

In order to reduce losses and provide future flexibility within LV networks, LV tapering policy may be re-examined. Adopted.

Action – Since 2012 WPD as part of the business as usual have installed link disconnecting boxes (LDB's) between LV substations on non-tapered LV mains cables, thereby providing the possibility of mesh connections and back feed potential under fault conditions. In addition since the start of 2015 WPD has amended the design policy and now all designs of the LV mains underground cable network are designed without cable size tapering. Networks shall be planned using either 185mm² or 300mm² Wavecon cables. The size chosen for a particular scheme will be used throughout that scheme and tapering is no longer considered.

Benefit for customers – All customers pay for the losses therefore by reducing the losses of the LV Mains circuits reduces the wasted energy that would be necessary to drive those losses, it also then by default frees up extra generation.

Recommendation 14

A review of DNOs' network modelling and analysis tools and capabilities may be required to support design engineers in applying new policies and processes relating to loss-inclusive network design.

Action – In order to forecast, what will happen on the WPD network in the future and to determine what is happening on the unmonitored parts of the network, the most powerful tool is computational modelling. WPD's LV system modelling tool includes losses calculations for each scenario used, but as one of the first measures WPD undertook was to increase the underground cable size and removed cable tapering this means upgrades are uniform across the company. The WPD 11kV system modelling tool also includes losses calculations, but as one of the first measures WPD undertook was to increase the underground cable size and removed cable tapering at 11kV this means upgrades are uniform across the company. At LV and 11kV, planners are able to comply with the majority of losses designs by using the uprated selection of cables and transformers made available in 2016.

At EHV WPD currently uses two system modelling tools, PSS/E and IPSA. PSS/E can create losses calculations, it is envisaged that PSS/E will become the standard system within WPD by 2020. Whilst all EHV designs are bespoke, WPD has completed work to provide templated solutions for generation connections, these templates incorporated the losses impacts.

Benefit for customers – Modelling effectively creates a virtual, fully monitored network which can then examine and test new ideas. Using the modelling tools WPD should be able to map where losses occur on the network, allowing for a targeted approach to loss reduction. Modelling can also be used to predict the effect of future changes to the network, so that the effect on losses of all possible future actions can be considered before the changes are actually carried out. Modelling should become even more useful once used in conjunction with smart meter data. By feeding the data into the model, this will be able to produce models of the network in real-time. Data at specific metering points can then be predicted and compared to the real data, to establish the success of the model. The software will need to be redesigned to incorporate this feature. Once this level of insight into the network is established, it will be possible to create more targeted losses strategies, leading to far more effective loss reduction activities.

Recommendation 15

There is an opportunity for considerable further learning in Europe and also from National Grid. It would be beneficial to share experiences of waste heat recovery installations among DNOs.

Action – WPD have carried out a provisional analysis with a heat pump manufacturer of using a heat pump in the oil line between the primary transformer and the cooling fins bank to heat the substation buildings.

Benefit for customers – This proved viable and WPD is now working with a primary transformer manufacturer to come up with a bespoke design, this is ongoing and will be rolled out as soon as complete, where the installation can be monitored with a view to make it BAU.

9 Appendix – SOHN recommendations

Recommendation 16

An Innovation Project, based upon learning from this initial Study, may be initiated in order to gather further insight into the technical and practical solutions which can be tested at more sites. The Project could be scoped to also tackle the regulatory and commercial market structural issues which will also need to be overcome to bring heat recovery and use into mainstream application.

Action – WPD is now working with a primary transformer manufacturer to come up with a bespoke design. This is ongoing and will be rolled out as soon as complete, where the installation can be monitored with a view to make it BAU.

Recommendation 17

DNOs may maintain an awareness of the potential for heat recovery when planning the installation of EHV transformers and seek to install more systems where the recovered heat may be of commercial use.

Action – WPD has discounted commercial use based on a report by Centre for Sustainable Energy (CSE). In addition, WPD has checked all its grid transformer sites with a view to creating a mini district heating system but because of the distance involved between building and transformers it becomes un-viable.

Recommendation 18

Further work on heat storage may be integrated with future trials work on recovery of heat from the distribution network, as it may improve the economics of more basic heat recovery systems.

Action – WPD has discounted commercial use based on a report by CSE. In addition WPD have checked all their grid transformer sites with a view to creating a mini district heating system but because of the distance involved between building and transformers it becomes un-viable.

Recommendation 19

DNOs should develop loss-inclusive network design strategies, based on their specific data, in order to ensure that the overall economic network operation and design criteria are met. This should include network modelling capability for answering 'what-if' questions in order to predict the impact of proposed network polices, projects and network demand forecasts on the overall reported network losses.

Action – WPD has created the Network Strategy team with responsibility for producing and assessing the impact of a range of Distribution Future Energy Scenarios (DFES), aligned with those developed by National Grid.

Benefit for customers – DFES have been produced for all four WPD licence areas to predict the impact of proposed network polices, projects and network demand forecasts on the overall reported network losses.

Recommendation 20

DNOs, with support from DECC and Ofgem, may determine the common basis in relation to loss mitigation and loss-inclusive network design and investment.

Recommendation 21

There is a need to establish the basis for assumptions on future electricity costs and carbon prices that would be used in loss-inclusive network investment that is consistent with the overall UK low carbon policy.

Action – WPD carry out the Ofgem Cost Based Analysis (CBA) with any Losses project to prove the case for the particular project. WPD use the Ofgem supplied value of £48.42/MWh in the CBA calculations. In addition, when converting carbon WPD use the DEFRA carbon conversion factors for both UK electricity (kWh) and Transmission & Distribution (kWh) the 2019 values for example are 0.2556 $kgCO_2e$ for Electricity and 0.02170 $KgCO_2e$ for Transmission & Distribution.

Benefit for customers – By adopting this method of assessment this ensures that the customer gets a consistent and auditable approach in CBAs.

Recommendation 22

Early in the RIIO-ED1 period, DNOs may develop more accurate means of measuring and reporting of distribution network losses.

Action – WPD has recently concluded the Losses Investigation project in conjunction with the Isle of Man, Manx Utility Authority and Loughborough University. One of the key issues identified is that measuring losses is difficult because the level of losses that are being looked for are small circa 7% and the losses on the Smart meter for example are -3.5% to +2.5%. This is also shown by the ENA Losses Measurement Report.

Benefit for customers – The ENA Technical Losses group employed WSP to recommend a new Losses mechanism which can be used by Ofgem during ED2, the proposal is to use a CBA method as adopted by other utilities around the world this would. By adopting this method of assessment this ensures that the customer gets a consistent and auditable approach in CBAs.

Recommendation 23

The DECC/Ofgem comparison of reported losses shows a discrepancy which may cause a distorted view of GB DNO losses, within industry, Government(s) and internationally.

Action – Currently DNOs and IDNOs are treated differently: DNOs are required to reduce losses but IDNOs are not. Where the IDNO network connects to the host DNO network at the Point of Common Coupling no metering is allowed therefore all the losses incurred on the IDNO network are all lumped together on that particular host DNO network, this then will show a discrepancy on that particular host DNO feeder. It is part of the ENA Losses group to ensure that this becomes a level playing field.

Benefit for customers – This would ensure that all new networks were designed to similar criteria and the ability to connect new LCT equipment can be meet.

Recommendation 24

DNOs may grasp opportunities to influence loss reporting in other countries and as it is presented in international studies. This is in order to ensure that GB DNOs' loss management performance is presented accurately.

Action – As part of the ENA Technical Losses group all DNOs report back into the group on what their respective owners carry out on losses and what each DNO has learnt from other sources. All these items are then discussed and considered by the group and whether to take them forward or not.

Benefit for customers – If losses can be reduced by adopting methods that have been trialled overseas then this will ultimately see a reduction of losses on the network which reduces the wasted energy that would be necessary to drive those losses, it also then by default frees up extra generation.

Recommendation 25

Industry, Government(s) and regulators should consider developing appropriate regulatory and commercial frameworks that would facilitate development of loss-generated heat schemes where economically justified.

Action – WPD have not seen a commercial heat solution yet.

Recommendation 26

DNOs' loss strategies may be 'stress tested' to demonstrate that they can deliver an objective of achieving an economic level of losses based upon avoided loss valuation, engineering costs and future network demands.

Action – The ENA LCT Group issued a contract to WSP Consulting to produce the LCT Planner Tool Design and Methodology.

Benefit for customers – This carried out essential stress testing of the methodology in practice to ensure the results achieved were correct.

10

Appendix – Project work

LV Templates

A substantial challenge for DNOs in preparing for the impacts of low-carbon policies is to understand how the network will be impacted and how best to respond. To achieve these goals, however, we first need to understand the dynamics of the LV network. The scale of this proposed project has been developed to test the ability to generate robust statistical results that can be confidently applied to the broader population with the minimum installation of equipment.

- Benefit from microgeneration numbers incorporated into NG schedule & dispatch;
- Template re-use – WPD carrying out this work means that other DNOs need not monitor a proportion of the network, as the templates the WPD project delivers enables them to understand their network capability without costly monitoring;
- Reduction in transformer failure – substation sensing gives a greater understanding of transformer cyclic loading, and can prevent overloading;
- Loss reduction benefit – substation sensing will provide greater understanding of transformer load cycles that will facilitate loss reduction through targeted CBA on old transformers having higher energy loss;
- Energy saving benefit – results from substation sensing templates will enable better utilisation of voltage tolerance. Results will be evaluated to calculate available headroom. Based on this, voltage on the network will be optimised resulting in energy savings;
- Network deferral benefit – network templates will be used to evaluate the available 'headroom' in terms of time of day demand/voltage compliance and whether further demand and DG capacity can be accommodated. This analysis will help in integrating EV and HP capacity on the network and using this capacity efficiently in times of peak demand.
  All objectives meet.

Losses Investigation

This Project aims to further our understanding of losses and determine the level of information needed to make accurate predictions. By fully monitoring the in-feeds and out-feeds of several LV and HV networks we will gain a much better picture of the flows on our network as well as certain losses critical parameters such as imbalance and power factor. With this modelled data as a reference we will then model and predict the losses with restricted data sets to establish the minimum data required to accurately predict losses.

The project approach has been to install monitoring on 22 HV and LV feeders, and then to develop methods of assessing technical losses on non-monitored HV and LV feeders using minimal additional monitoring. The monitored feeders provided corroborated actual feeder loss information to further our understanding of technical losses, and acted as a control group for testing alternative methods of assessing losses.

A key outcome of the project has been that methods have successfully been developed to assess losses on HV and LV feeders that require no more monitoring information than is available through business-as-usual channels. These methods are based on power flow calculations for individual feeders, using feeder-specific topology and high time-resolution load models over a one year period. These methods have been calibrated against the monitored feeders, and agree well with losses calculated using the full monitoring data.
In addition, the developed methods have been successfully applied to over 75% of the HV and LV feeders in the East Midlands license area, involving over 71,000 network and load feeder models.
The project has therefore demonstrated the feasibility of widespread feeder-specific assessment of losses and has created detailed information characterising losses on HV and LV feeders in the East Midlands.
All objectives meet.

Open LV

OpenLV deployed a low cost substation intelligence platform, LV-Cap™, which is a hardware device to enable substation data inputs, such as voltage, current and temperature to be captured and used via 'apps' developed and installed on the hardware platform. This will act as a hub for a range of complementary purposes, including: Network Capacity Uplift: demonstrating capabilities of LV-Cap™ through deployment of real time thermal ratings, load management applications & temporary network meshing automation to provide LV capacity uplift.

Community Engagement: establishing a community engagement method to enable communities to develop innovative algorithms and applications on LV-Cap™ to enable them to better understand their electricity use (and generation). OpenLV Extensibility: facilitating academics & companies to develop innovative algorithms & applications that could be deployed on LV-Cap™ to both improve network performance & increase visibility of LV networks.

SDRC	Description	Due Date	Status
SDRC 1	Specification, Design and Factory Testing of the overall OpenLV Solution	27/10/17	Delivered
SDRC 2.1	Community Engagement Plan & Interim Results of Assessing Market Potential (Methods 2 & 3)	31/12/17	Delivered
SDRC 2.2	Identification of Target Networks (Method 1), Update of Assessing the Market Potential (Methods 2 & 3) and Detailed Trial Design for all Methods	30/05/18	Delivered
SDRC 3	Learning from Deployment of the Overall OpenLV Solution & Standard Guidelines for Application Development	08/02/19	Delivered
SDRC 4	Learning Generated from the OpenLV Project Trials for All Methods	31/01/20	In progress
SDRC 5	Knowledge Capture, Dissemination & Transferring the OpenLV Solution to Business as Usual	30/04/20	Not Started

What is Falcon

The key objectives of FALCON are detailed in Table 5 below and we have detailed where we believe the project has been successful:

Objective	Status	Status
The Method comprises a Scenario Investment Model (SIM) linked to a network trials area.	We achieved this objective. The SIM has been developed and successfully run many Low Carbon Future Scenario's.	✓
It will trial four technical and two commercial alternatives to traditional reinforcement.	We achieved this objective and the final results were disseminated via a Final Report for each technique and presented on 10th November to the wider stakeholder audience.	✓
The trials area will prove the practically of these techniques.	We achieved this objective. We have significant learning as detailed within the spreadsheet in order that the techniques can, if chosen, be implemented far more readily.	✓
The SIM will identify network constraints under multiple future network load scenarios and determine the most cost-effective and timely combination of techniques to resolve them.	We achieved this objective. More information on the results can be found in the SIM Final Report a link to which can be found in Section 15.5.	✓
The trial area will comprise six primary substations located on a mix of rural and urban networks representative of 90% of the national 11kV network.	This was achieved through the use of Milton Keynes, which was a mix of urban and rural networks.	✓
The objectives of FALCON are closely aligned with those of the UK Low Carbon Transition Plan and ED1.	We met this objective and moreover were able to run the SIM to inform an ED1 plan for the trials area. The results of this are within the SIM Final Report.	✓
In addition to enabling the uptake of low carbon technologies, FALCON will deliver faster and cheaper 11kV connections and reduced DUoS charge increases for all.	The trial techniques have resulted in disseminated learning that show a range of potentials to facilitate the uptake of low carbon technologies by customers that connect to distribution networks. The technique trials and the results from scenario modelling of the future suggest that whilst some delay in reinforcement work is possible from application of the techniques, conventional reinforcement will still have a major role in the provision of networks of the future.	✓
It will generate learning applicable to all DNOs, shared through established LCNF dissemination channels.	Objective met - FALCON has a wealth of valuable knowledge and learning that we are sharing with stakeholders and have been throughout.	✓
In addition to a net financial benefit of £1.2m from the four year project, we estimate that a national rollout of FALCON will realise a £660m financial benefit over 20 years and will save over 680 ktonnes of CO_2 by 2050 (accounting for an additional £36m of benefits).	Objective met by virtue of the demonstration through the SIM that the techniques demonstrated appear to show a 20% reduction in cost on average when compared to conventional reinforcement. FALCON delivered as planned and provides a good foundation for further work in this area.	✓

Equilibrium

Network Equilibrium set out to address the Problem in a more cost effective manner than the traditional approach. The new approach involved developing new design and operating processes to transform passive distribution networks into active distribution systems through the use of new technologies, including monitoring and control systems.

Number	Objective
1	Increase the granularity of voltage and power flow assessments, exploring potential amendments to ENA Engineering Recommendations and statutory voltage limits, in 33kV and 11kV networks, to unlock capacity for increased levels of low carbon technologies, such as DG.
2	Demonstrate how better planning for outage conditions can keep more customers (generation and demand) connected to the network when, for example, faults occur. This is particularly important as networks become more complex, with intermittent generation and less predictable demand profiles, and there is an increased dependence on communication and control systems.
3	Develop policies, guidelines and tools, which will be ready for adoption by other GB DNOs, to optimise voltage profiles across multiple circuits and wide areas of the network.
4	Improve the resilience of electricity networks through FPL technologies, which can control 33kV voltage profiles and allow power to be transferred between two, previously distinct, distribution systems.
5	Increase the firm capacity of substations, which means that the security of supply to distribution customers can be improved during outage conditions, leading to a reduction in customer interruptions (CIs) and customer minutes lost (CMLs).

Success criteria

FSP	Project Direction	Description	Evidence	Status
9.1	SDRC-1	Detailed design of the Enhanced Voltage Assessment (EVA) Method	1. Conduct a questionnaire and workshop with GB DNOs (and other relevant stakeholders) to discuss and explore amendments to existing statutory voltage limits and Engineering Recommendations; 2. Share a report with the industry detailing evidence for the limiting factors for 11kV and 33kV statutory voltage limits including new and existing transformers, tap changers, cables, overhead lines, switchgear, CTs, VTs customer equipment, stating the limiting factors and safety margins will be detailed for future evaluations; 3. Issue a discussion paper suggesting where the statutory limits for 11kV and 33kV networks could be amended; and 4. A DNO relevant specification and guide to implementation of an EVA power system analysis tool.	✓
9.2	SDRC-2	Detailed design of the System Voltage Optimisation (SVO) Method	1. Create a technical specification (including performance metrics) with input from UK DNOs; 2. Sharing of the SVO algorithm design and considerations to facilitate SVO; and 3. Make detailed designs available explaining how SVO will be installed for DNOs and interested parties.	✓
9.3	SDRC-3	Detailed design of the Flexible Power Link (FPL) Method	1. Share FPL specification used in the tender; 2. Detail the performance metrics of how FPL will be measured; 3. System incorporation design, physical and protection; 4. Sharing detailed designs of how the FPL will be installed by request of other DNOs; 5. Define the key considerations when incorporating a FPL within 33kV networks; and 6. Record of knowledge and learning throughout the design process that would be relevant to the incorporation of FPLs into the 11kV network.	✓

FSP	Project Direction	Description	Evidence	Status
9.4	SDRC-4	Trialling and demonstrating the EVA Method	1. A report demonstrating the potential benefits of adjusting the statutory limits; 2. Demonstration of EVA power system analysis software for planning and operational uses; 3. Recommendations to GB DNOs on how to model the SVO control components; 4. Recommendations to GB DNOs on how to model the FPL; and 5. Use the EVA power system analysis models to quantify the capacity released for each of the Methods, individually and when combined together. These will be compared to the estimates included in Section 4.1.4 of the FSP.	✓
9.5	SDRC-5	Trialling and demonstrating the SVO Method	1. Installation of SVO across 8 BSPs and 8 primary substations; 2. Report on the installation of SVO equipment at BSPs and primary substations; 3. Report on the implementation of the SVO solution; 4. Report on the performance and capacity released by the SVO Method; and 5. Sharing of policies with other DNOs.	✓
9.6	SDRC-6	Trialling and demonstrating the FPL Method	1. Installation and commissioning of the 33kV FPL; 2. A guide to implementation and use of FPL, detailed evaluation of the performance, capacity increased through the technique in the report; 3. Sharing of policies with other DNOs; and 4. An assessment of what has been learnt through the trial that would be relevant to the deployment of FPLs across the 11kV networks.	✓
9.7	SDRC-7	Trialling and demonstrating the integration of the EVA, SVO and FPL Methods	Publication of a report detailing: 1. Quantification of how all three techniques can be incorporated together and the impacts; 2. Analysis of the passive and active generation and demand capacity that can be released across the eight different BSPs; and 3. Cost-benefit analysis of the Methods, deployed separately and integrated, including the capital expenditure and projected operations and maintenance costs.	✓
9.8	SDRC-8	Knowledge capture and dissemination	1. Knowledge and learning dissemination reports and presentations; 2. Network data being made available for each of Equilibrium's Methods; 3. Six-monthly progress reports submitted to Ofgem throughout the project; 4. Equilibrium project presentations delivered at eight industry conferences during the course of the project from March 2015 to June 2019; and 5. Equilibrium project presentations delivered at each of the LCNI } conferences during the course of the project.	✓

FlexGrid

The objective of FlexDGrid was to develop and trial an advanced Fault Level management solution to improve the utilisation of DNO 11kV (HV) electricity networks while facilitating the cost-effective and early integration of customers' generation and demand connections. The methods deployed for FlexDGrid would provide learning and practical material to provide DNOs with the capability to defer or avoid costly and prolonged network reinforcement, while improving security of supply.

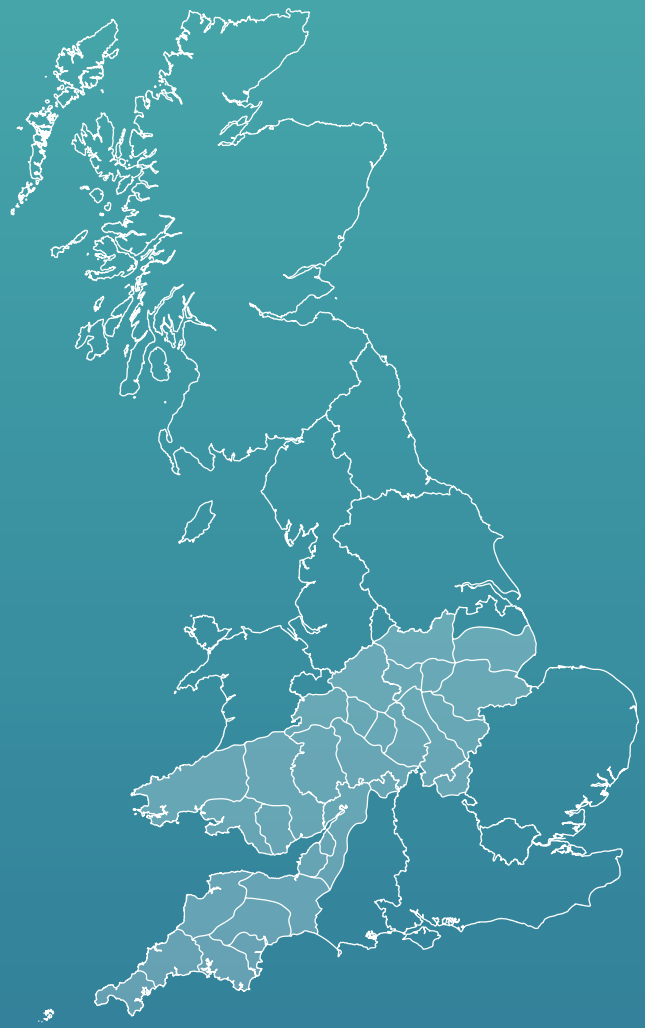
The project originally identified four main objectives as detailed in the Full Submission Pro-forma and listed opposite:

(i) Defer/avoid capital investment for customers and DNOs;
(ii) Avoid long connection lead times for low carbon generation;
(iii) Increase network efficiency and reduce Customer Interruptions (CIs) and Customer Minutes Lost (CMLs); and
(iv) Secure long term sustainable and affordable electricity prices with assisted living benefits from Combined Heat and Power (CHP).

Table below lists the Successful Delivery Reward Criteria encompassing the main deliverables for FlexDGrid.

FSP	Project Direction	Description	Evidence	Status
9.1	SDRC 1	Develop an enhanced Fault Level assessment process	· Using the Birmingham HV electricity network to trial the Enhanced Fault Level Assessment process. · A workshop with other DNOs to discuss the Enhanced Fault Level Assessment process. · A publication on the Enhanced Fault Level Assessment process to be shared with other DNOs.	✓
9.2	SDRC 4	Simulation and application of the Enhanced Fault Level Assessment process to demonstrate what can be achieved with customers' connections	· A developed and tested Enhanced Fault Level Assessment process with endorsement from WPD planning and design engineers. · Quicker response to customers' connections applications. · Characterisation of the substations to determine the suitability of potential Fault Level Mitigation Technologies. · Open source Fault Level Mitigation Technology models. · Quantification of additional capacity that will be unlocked to accommodate future customers' connections.	✓
9.3	SDRC 2	Confirmation of project detailed design	· Confirmation and justification of the five substation sites selected for Fault Level mitigation and ten substation sites selected for Fault Level monitoring. · Availability of detailed design documents to other DNOs.	✓
9.4	SDRC 11	Development of novel commercial frameworks with generation and demand customers	· Novel commercial frameworks are readily available for use in customers' connection applications within the project trials. · Produce a `Connections Options' document and dissemination to other DNOs, customers and other interested parties.	✓
9.5	SDRC 7	Installation and open-loop (non-network controlling) tests of Fault Level monitoring equipment	· Installation of equipment in ten Primary Substation sites. · Open-loop (non-network controlling) test results being disseminated.	✓
9.6	SDRC 8	Installation and open-loop (non-network controlling) tests of Fault Level mitigation equipment	· Installation of equipment in five (changed to three as part of a formal Change Request) Primary Substation sites. · Dissemination of open-loop (non-network controlling) test results and system-level learning.	✓

FSP	Project Direction	Description	Evidence	Status
9.7	SDRC 9	Closed-loop (network controlling) tests of Fault Level monitoring and mitigation equipment	· Dissemination of closed-loop (network controlling) test results and system-level learning.	✓
9.8	SDRC 10	Analysis of test results, evaluating and quantifying the benefits of the Solution and applicability to GB HV electricity networks	· Knowledge dissemination: · Network data being made available. · Six-monthly progress reports submitted to Ofgem throughout project. · Eight industry conferences attended and presented by December 2016. · LCNF Annual Conference. · Publication of reports.	✓
9.9	SDRC 3	Hold a workshop, inviting all GB DNOs and other interested parties. At the workshop, the Implementing DNO will provide an overview and expected performance of all three methods	· Hold a workshop with other GB DNOs by 31 October 2013. · Written responses to the consultation from each GB DNO submitted with the report required under A) Methodology of Method Gamma of 3. CONDITION PRECEDENT.	✓
N/A	SDRC 5	Delivery and Authority approval of report as required under B) Value for money of 3. CONDITION PRECEDENT before issuing Invitation to Tender for Fault Level mitigation technologies 31 December 2013	· Delivery of a report to the Authority under B) Value for money of 3. CONDITION PRECEDENT. · Authority approval that the competitive procurement process will be undertaken in a way that will deliver best value for money.	✓
N/A	SDRC 6	Delivery and Authority approval of report as required under A) Methodology of Method Gamma of 3. CONDITION PRECEDENT before signing contracts for Fault Level mitigation technologies. 31 December 2013	· Delivery of a report to the Authority covering points (i) to (vi) under A) 0Methodology of Method Gamma of 3. CONDITION PRECEDENT. · Authority approval that there is sufficient evidence that GB DNOs consider that proceeding to Method Gamma would provide the learning outlined in the Full Submission pro-forma.	✓



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